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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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RESILIENT CHAIRS AND FERRO CONCRETE SLEEPERS.

IN 1912, Louis Green, M.Inst.C.E., of the East Indian Railway, and R. St. George - Moore, M.Inst.C.E., of Westminster, investigated the question of ferro-concrete sleepers, and after a very careful study of existing patents and other available material dealing with this subject, came to the conclusion that the points which required fuller investigation and which were essential to the design of an effective ferro-concrete sleeper were: (1) To obtain resilience if possible equal to that of the wooden sleeper and cast-iron chair combination. (2) Improve the connection between the chair and the ferro-concrete block. (3) Scientifically arrange the reinforcement to meet the strains due to the variations in the packing of the road. (4) Increased facilities for handling. On the present page and page 192 we illustrate the sleeper adopted to combine these essential points.

In describing the sleeper it may first be shown how the design conforms to the four desiderata enumerated. As regards the first, and taking the chairs for bull-headed rails, it will be seen from Figs. 1 to 4, that the chair is made of wrought steel plate forming a suspension loop. In the first experiments the steel plate was 6 in. wide and $\frac{3}{8}$ in. thick, the outer jaw of the chair was formed so as to come close to the head of the rail to prevent excessive movement of the rail in the event of the key dropping out of the chair. Experience gained proved that although a chair 6 in. wide gave a wider bearing to the rail, the increase of the stress at the edge of the plate was too great, and that it was not necessary to have the outer jaw close to the head of the rail, which facilitated the handling of the rail. In the second series of experiments the chair was made of 4-in. by $\frac{1}{2}$-in. plate. It was at first thought that plates $\frac{1}{2}$ in. thick would be too rigid, and to remedy this the legs were slightly curved, but this was found unnecessary as the chair was elastic enough without it. Adequate clearance was provided between the head of the rail and the jaw to enable the rail to be placed in position and removed easily. There is a tendency of the jaw to close slightly when the chair is depressed, but it springs back immediately the pressure is removed. Whether the key is in position or not appears to make very little difference to the distortion of the chair under a load.

Chairs for flat-footed rails have little resilience by virtue of their shape, but this difficulty has been effectively overcome as proved by the trials, by making the table of the chair longer than the width of flange of the rail (see Figs. 5 to 8, and the perspective views, Figs. 15 and 16). The attachment consists of a bolt with a square nut and a spring washer, the nut is made to lie close against the tie-rod, and therefore cannot turn. The spring washer provides the necessary elasticity in the attachment.

As to the second desideratum, "To improve the connection between the chair and the ferro-concrete block," the chair should enter into direct combination with the reinforcement and the form shown was adopted; this form allows of the resolution of the forces in the chair directly into the lines of reinforcement provided for each specific strain.

To meet the third requirement—"Scientifically to arrange the reinforcement to meet the strains due to the variations in the packing of the road,"—various system of reinforcement have been covered by the patents. In the system adopted, and finally tried by the Government Inspectors (Figs. 1 to 4), the distribution of the stresses in the reinforcement is determined largely by the packing of the sleeper. If it were possible to have the sleepers packed uniformly, the amount of reinforcement might be considerably reduced. But as ideal conditions in permanent-way maintenance are very seldom realised, it is necessary to consider what really does happen when the sleepers are badly packed. Diagrams, Figs. 12 to 14, roughly indicate three not uncommon states of the ballast under the sleepers, and the resulting bending moments from a wheel load of 9 tons. If the bearing on the ballast were uniform, but little reinforcement would be required to take the tensile strains along the top surface of the sleeper. On the other hand, if the sleepers bore on the ballast over the middle third, the lower members of the reinforcement would be in compression, and the upper members in tension. But if the sleepers were only supported at the ends instead of at the middle or uniformly, the lower members would be then in tension and the upper in compression. In both of these cases the bending moment is greater than in the first. In addition to the tension due to the bending moments which has to be provided for, provision has also to be made to take the direct tension resulting from the horizontal components of the wheel load transmitted by the legs of the chair to the concrete. It will be seen from the diagrams that there is no tensile strain acting along the top surface outside the middle third in any of the circumstances dealt with above. The reinforcement has, therefore, been designed to resist the maximum combined stresses which would be caused by the standard wheel-load when the sleeper is bearing unevenly on the ballast.

Figs. 12 to 14 show the three conditions of packing and the resultant stresses. The following data were used:—

Wheel load, 9 tons.
Steel, working stress, in tension, 8 tons per square inch.
Concrete, working stress, in compression, 0.25 tons per square inch.
Concrete, working stress, in tension, 0.025 tons per square inch.
Concrete, working stress, in shear, 0.05 tons per square inch.
Adhesion of steel reinforcement to concrete, 100 lb. per square inch of surface in contact.
Modulus of elasticity of steel, 13,000 tons per square inch.
Modulus of elasticity of concrete, 876 tons per square inch.
13,000 by 876 equals 15, the usual allowance.

On Figs. 1 to 4 the lower tension members are marked *e*, *e*, *e*. The upper tension members are marked *f*, *f*, *f*. The direction tensions from the chair are taken by *h* and *g*. The tensions caused by the transverse bending moments are taken by *b*, *b*, *b*. To these must be added the top and bottom members of the side frames *d*, *d*, *d*.

To increase facilities for handling, it was decided to make each sleeper in two parts, with the result that the Government Inspector in his report said, "This sleeper is easier to handle than any other pattern that I have seen."

For bull-headed chairs the tie-rods are attached to the chairs by ordinary gibs and cottars. For flat-footed rails they can either be attached in the same manner or by the patent device shown by Figs. 9 and 10, by means of which the number of loose parts is materially reduced. Where it is desired to insulate one rail from the other for the purpose of using the rails as conductors for electric currents for signalling purposes, special tie-rods can be inserted without changing any other part of the permanent way. The special tie-rod, provided with a central insulating device, is shown by Fig. 11. These chairs and sleepers are, we may mention, protected by patents.

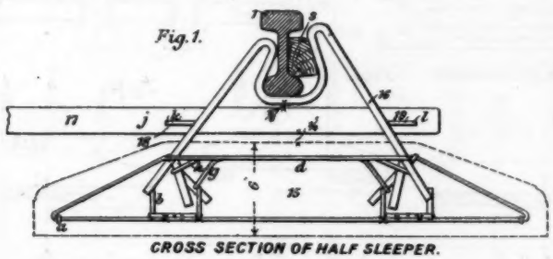
The present prices of materials, and the impossibility of obtaining them, renders estimating very difficult, but the following data are regarded as sufficient for estimating the cost of the sleepers with fair accuracy from time to time when the prices of materials are known.

Concrete in Complete Sleeper.

	Cub. Ft.
For double-headed rails—	
Cement (for two slabs)	0.8
Sand (for two slabs)	1.2
Ballast (for two slabs)	2.5
	Lb.
Two chairs	40.3
Two sets of reinforcement	20.3
One tie-bar (for 5-ft. 6-in. gauge)	21.8
Two cottars	1.1
Two gibs	0.6
For flat-footed rails—	Cub. Ft.
Cement (for two slabs)	0.8
Sand (for two slabs)	1.2
Ballast (for two slabs)	2.5
	Lb.
Two chairs	25.0
Two sets of reinforcement	20.0
One tie-bar	20.8
Two cottars	1.1
Two gibs	0.6

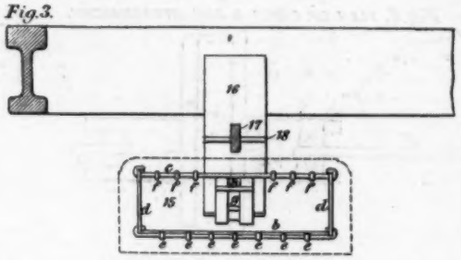
On January 25, 1914, eleven sleepers of the original design—6-in. by $\frac{3}{8}$-in. plate chairs and wire reinforcements—were laid on the Shalimar branch. The permanent way on the branch consists of

Fig. 1.



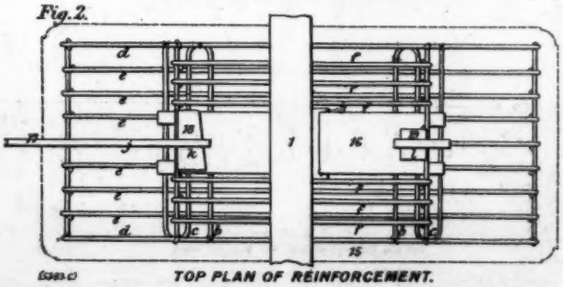
CROSS SECTION OF HALF SLEEPER.

Fig. 3.



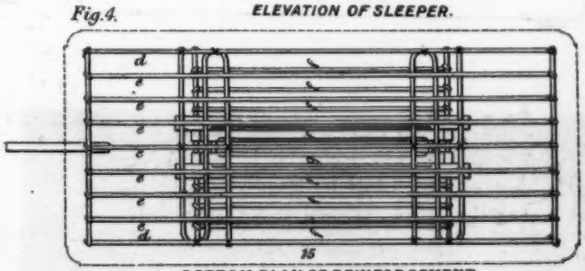
ELEVATION OF SLEEPER.

Fig. 2.



TOP PLAN OF REINFORCEMENT.

Fig. 4.



BOTTOM PLAN OF REINFORCEMENT.

75-lb. double-headed steel rails and cast-iron D.O. sleepers. Sixteen goods trains, eight loaded and eight empty, pass over the branch daily at a speed not exceeding 10 miles an hour. Heavy saddle and 46-ton tank engines are employed for shunting and running out these trains. The sleepers were well packed with stone ballast after they were laid, and have been attended to by a permanent-way gang at intervals of about a fortnight during the first month, and about once in three months since. The sleepers have stood very well and have given no trouble; moreover, they were subjected to a severe test two months after they were put into the road. A wagon in a train of empties got derailed at points not far from the trial sleepers, and was dragged some distance before the driver pulled up. One wheel passed over the sleepers about 8 in. inside the track and the other outside, the inner wheel bumping over the concrete and tie-bars and the outer over the sides of the chairs. The tie-bars were, of course, damaged, but not sufficiently to render the road unsafe. One sleeper had a corner measuring 6 in. by 3 in. broken off by a blow from the wheel flange, a second had a slight crack, a third only a slight mark, but none of the other sleepers were damaged, nor were the chairs over which the wheel passed injured in any way. Not a single sleeper was displaced from its position by impact with the derailed vehicle. A similar accident over cast-iron D.O. road would have caused much more damage and interruption to traffic.

On February 22, 1914, eleven sleepers were laid on one of the shunting lines in Howrah goods yard. On March 8 six more sleepers were laid alongside the first lot. The type of permanent way in the goods yard is the same as on the Shalimar branch, but the number of vehicles and engines passing over the shunting line is much greater. On an average one engine and about 15 vehicles shunt over it 480 times in 24 hours, at a speed from 5 miles to 10 miles. The engines used vary from 46 tons to 68 tons weight. In addition to shunting, six goods trains run over the siding daily. Of the 17 sleepers, one concrete slab failed a week after it was laid, five failed 10 weeks after, three 13 weeks after, and two 16 weeks after they were laid.

On May 15, 1914, thirteen sleepers, with modified chairs, reduced thickness of concrete and 85-lb. steel double-heated rails, were laid on the shunting line near the first lot. The object of reducing the thickness of the concrete was to discover the point of minimum thickness at which the sleeper would begin to fail, and so obtain reliable data for determining a convenient factor of safety. Of these 13 sleepers, six failed on May 16, two on May 17 two on May 18, 4 on June 1, and five on June 14.

The remaining seven slabs were removed from the road a month later. It was instructive to observe how the cracks in the concrete originated and developed, and how closely their position coincided with the planes of maximum tensile stress. More interesting even than that was the indication by the cracks of a complete reversal of stresses from compression to tension.

A very important question arises in connection with these trials—Why have the sleepers failed in the shunting siding and not in the Shalimar branch, where they have now served for thirteen months? Possibly the phenomenon of fatigue may have something to do with the explanation; the period of rest between successive shunts being short and having a very low margin of safety the reinforcement and concrete could not recover sufficiently between trains. All the cracked sleepers were broken up and carefully examined. There was no doubt that the wires could not safely take the tensile strains imposed by the bending moments and horizontal components of the load. Other defects such as bad joints between the wires and frames, and bad spacing of upper and lower members, had also weakened the sleepers appreciably.

The foregoing conclusions led to a further investigation of the stresses in the sleepers produced, by bad packing and heavy traffic, and the reinforcement modified in accordance with the calculated results. On November 24, 1914, and January 20, 1915, seventy sleepers with improved reinforcement and chairs were laid with 88½-lb. double-headed steel rails in the third line between Konnagar and Rishra stations, mile 8½. The third line is partly laid with 75-lb. and partly with 85-lb. steel rails, cast-iron chairs and wooden sleepers, well packed with good stone ballast. Traffic over the

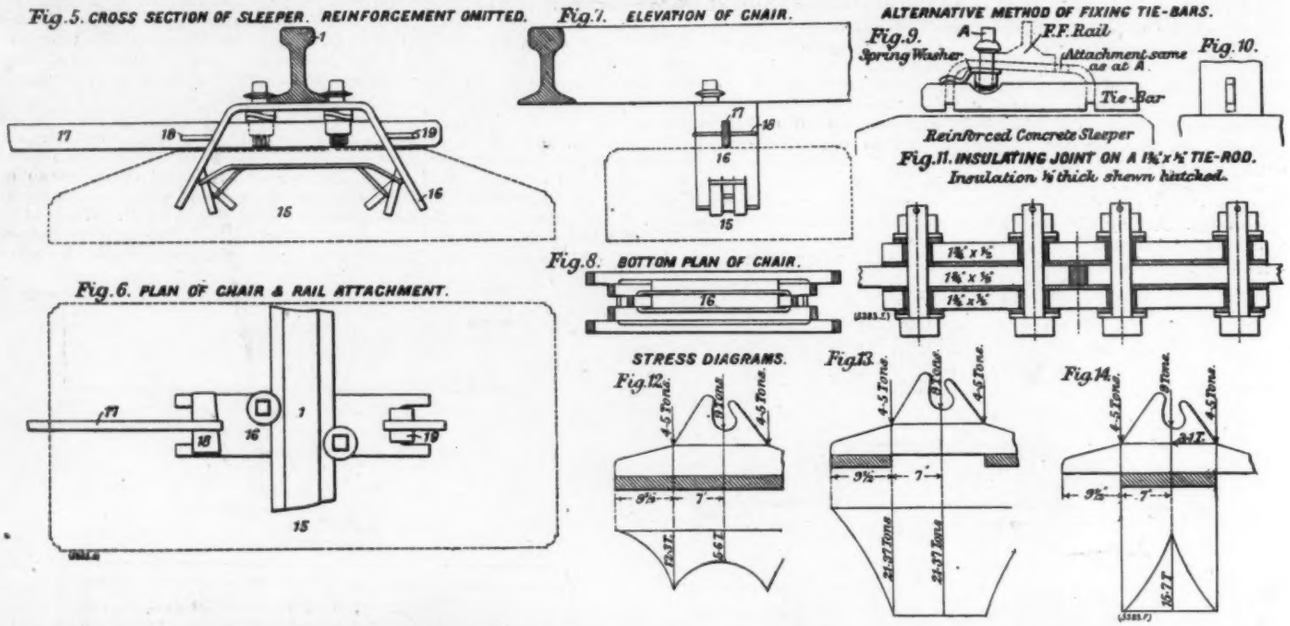


Fig. 15.

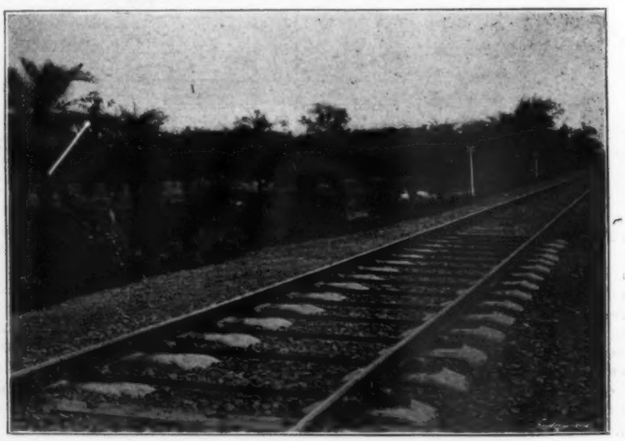


Fig. 16.

THE SCIOTOVILLE BRIDG[E] O[VER]

MR. GUSTAV LINDENTH[AL] NEW

(*For Descripti[on] see Page*

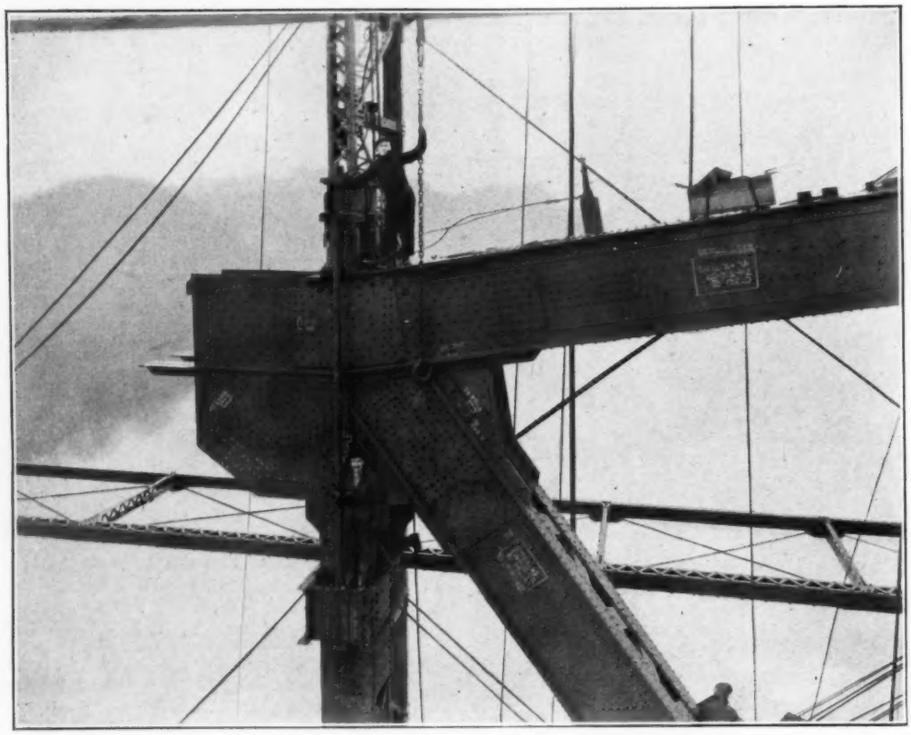


FIG. 10. MAKING CONNECTIONS AT POINT U 14.

FIG. 11. REVOLVING INCLI[NED] WEB

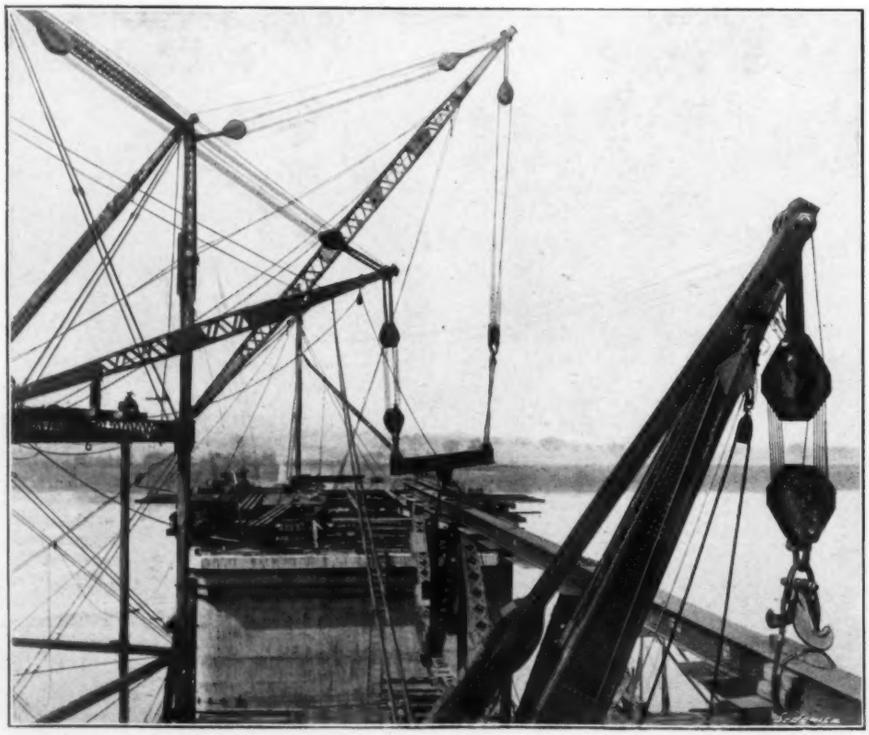


FIG. 13. LIFTING 80-TON TRUSS OF DECK SPAN.

FIG. 14. LIFTIN[G]

IDG OVER THE OHIO RIVER.

ENTR NEW YORK, ENGINEER.

Descrip ee Page 193.)

INCLIN WEB MEMBER M 19—U 18.

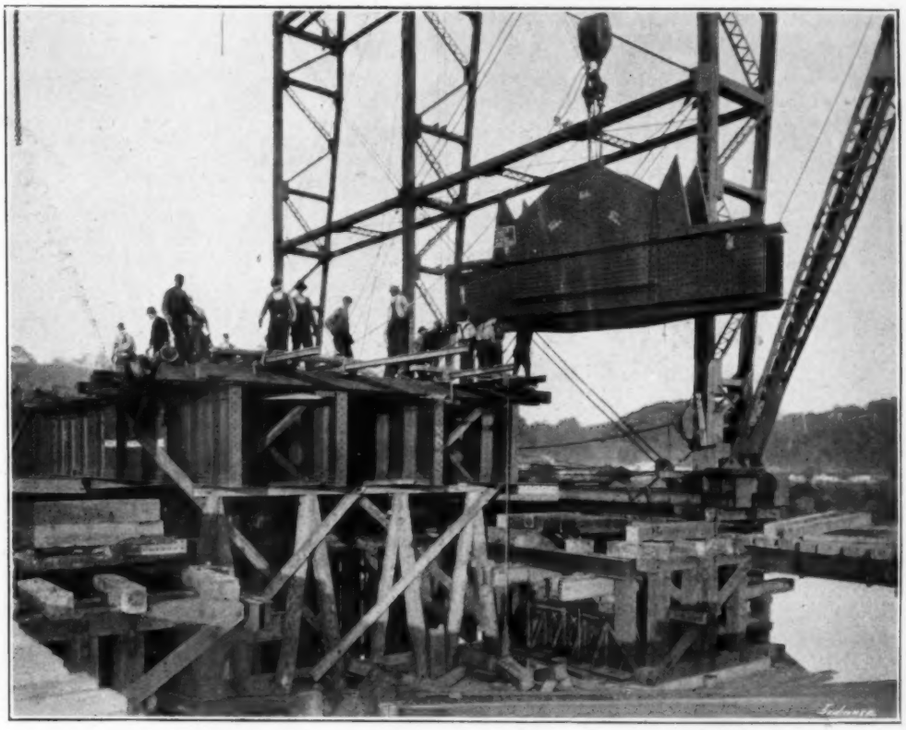


FIG. 12. LIFTING BOTTOM CHORD SECTION L 20

LIFTIN TRUSS MEMBERS.

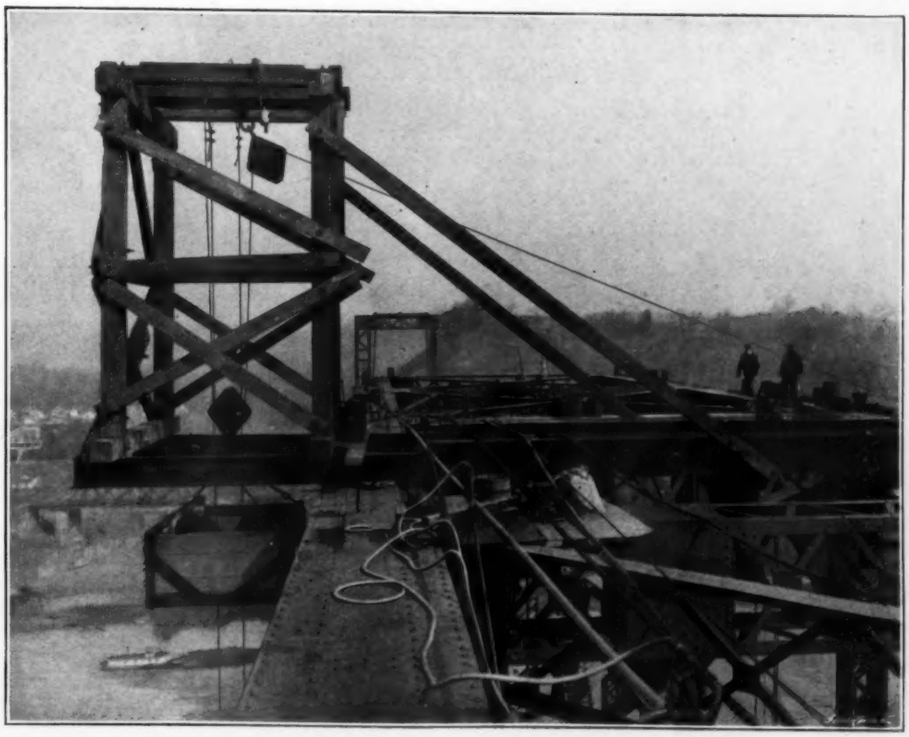


FIG. 15. PASSENGER ELEVATOR.

line is mixed, and the speed limit of passenger trains is 30 miles an hour. The sleepers have had the same attention in the matter of maintenance as was given to the trial sleepers in other places. They have been carefully watched since they were laid, and up to the date, March 5, 1915, nothing wrong had been observed. Mr. Derry, the permanent-way inspector in charge, reports that the sleepers are easy to pack and easy to maintain in regard to alignment, level and gauge. Passenger trains, he states, frequently travel over the road at a greater speed than 30 miles, and that the running is springy and smooth. The average number of trains daily is about 12 and two light engines. The engines used vary up to 78-ton tank engines.

On February 3, 1915, the agent, chief engineer and Government Inspector of Railways inspected the sleepers and as a result of this inspection it was agreed to have the next trial made in the line over which all the East Indian Railway mails and express trains travel. The schedule speed over the line is 45 miles, but when time has to be made up, drivers of through trains do not hesitate to exceed that limit, and 60 miles an hour is then not an uncommon achievement. In May, 1915, the decision of the chief engineer was carried into effect, and the sleepers moved from the third line to the main line, and further sleepers added, making a total length of 400 yards.

In 1916, Mr. E. A. C. Lister, senior Government Inspector of Railways, Circle No. 1, Calcutta, reporting on this sleeper, says: "Mr. Green, district engineer, Howrah, showed a reinforced concrete sleeper which had stood a year's trial on the down line between Howrah and Burwan without any sign of failure. The sleeper is on the principle of the D. and O. plate, *i.e.*, in two halves tied with a tie-bar. The bearing area is about 25 per cent. greater than that of the D. and O. plate. This sleeper is easier to handle than any other pattern I have seen, the total weight of a sleeper is 200 lb., of which one-half only requires to be lifted for laying purposes at a time. The cost is given as Rs. 6/8/– per sleeper complete for 85-lb. or 88½-lb. B.H. rails, and Rs. 5/8/– for 90-lb. F.F. rails."

In 1917, Mr. A. Pakenham-Walsh, senior Government Inspector of Railways, Circle No. 1, Calcutta, reported: "Permanent way.—The running on the whole was very good. The reinforced concrete sleepers referred to in paragraph 5 of last year's report were examined and found to have stood another year's heavy traffic very well. These sleepers were said to cost only Rs. 6/8/– for flat-footed rails and Rs. 7/8/– for double-headed rails, including fastenings. A vibrating table has been received for making these sleepers. When the first cost and probable life are taken into account, it looks as if these sleepers would drive wooden and metal sleepers out of the market."

Comparison of cost with that of other sleepers: Owing to the enhanced value of some materials, the impossibility of obtaining others at present, and also probably in the future, a fair comparison is practically impossible at the present time. The following comparison is based on experience on the East Indian Railway.

Cost per mile per annum of wooden sleepers:

The life is taken at twelve years for the sleeper, thirty years for the cast-iron chairs and spikes, and three years for the wooden keys.

Number of sleepers per mile, 2,200.
Weight of sleepers per mile, 180 tons.

	£	£
Cost of sleepers per mile—2,200 at 7*s.*	770.0	
Cost of freight and laying ditto	180.0	
	950.0	
Deduct value of scrap	75.0	
Net cost of sleepers	875.0	
Annual reserve fund at 3½ per cent. to provide for renewals at the end of twelve years' life, at compound interest		59.9
Interest at 4 per cent. on first cost per annum		38.0
Cost of 4,400 chairs and spikes	372.5	
Freight and laying	86.8	
	459.3	
Deduct value of scrap	173.6	
Net cost of chairs and spikes	285.7	
Annual reserve fund at 3½ per cent. to provide for renewals after thirty years' life, at compound interest		5.5
Interest at 4 per cent. per annum on first cost		18.4
Wooden keys, three years' life		5.5
Annual cost per mile of wooden sleepers		127.3

On the same basis, with wooden sleepers at 5*s.* each, the annual cost per mile would be £100.09

In considering the cost of cast-iron and ferro-concrete sleepers an allowance has to be made for breakages which do not occur with wooden sleepers. The breakages with cast-iron sleepers is greater than it is expected to be with ferro-concrete sleepers, as proved by experience gained in the trials hereinbefore described.

Cost of cast-iron pedestal sleepers with connecting tie-bars as now in use. Life of sleepers thirty years:—

Weight of pedestal sleepers in 1 mile of road, 231.3 tons.

	£	£
Cost of sleepers per mile, at 6*l.* per ton, including freight and laying	1,387.8	
Deduct value of scrap	462.6	
Net cost of sleepers	925.2	
Interest at 4 per cent. per annum on first cost		55.5
Cost of annual renewals due to breakages		30.8
Annual reserve fund at 3½ per cent. to provide for half-renewals after thirty years, at compound interest		9.0

Weight of tie-bars and keys, 32.4 tons.

	£	£
Cost of tie-bars and keys per mile, at 8*l.* per ton	259.2	
Deduct value of scrap	64.8	
Net cost per mile	194.4	
Interest at 4 per cent. per annum on first cost		10.4
Annual reserve fund to provide renewals after thirty years, assuming no renewals are necessary during that period		3.8
Annual cost per mile of cast-iron sleepers		109.5

Ferro-concrete sleepers: Up to the present no experience of the life of these sleepers is available on which to base a comparison, the figures are therefore given for twenty, twenty-five and thirty years' estimated life.

Sleepers for bull-headed rails:—

	£	£
Cost of 2,200 sleepers complete with chairs, tie-bars, gibbs and cottars, at 10*s.* 6*d.* each	1,155.0	
Deduct value of scrap, at 2*l.* per ton for 50 tons	100.0	
Net cost of sleepers	1,055.0	
Annual cost on basis of twenty years' life—		
Cost of annual renewals due to breakage		26.37
Interest at 4 per cent. per annum on first cost		46.2
Annual reserve fund at 3½ per cent. to provide for half-renewals after twenty years' life, at compound interest		19.0
Keys (same as wooden sleepers)		5.5
Net cost of sleepers		97.07
Annual cost on basis of twenty-five years' life—		
Cost of annual renewals due to breakage		21.10
Interest at 4 per cent. per annum on first cost		46.2
Annual reserve ditto after twenty-five years' life		14.0
Keys		5.5
Net cost of sleeper		86.80

Annual cost on basis of thirty years' life—

	£
Cost of annual renewals due to breakages	17.6
Interest at 4 per cent. per annum on first cost	46.2
Annual reserve ditto after thirty years' life	10.5
Keys	5.5
Net cost of sleeper	79.8

For flat-footed rails—

	£	£
Cost of 2,200 sleepers complete with chairs, tie-bars, gibbs, cottars, bolts and washers, at 9*s.* 6*d* each	1,045.0	
Deduct value of scrap, at 2*l.* per ton for 40 tons	80.0	
Net cost of sleepers	965.0	

Annual cost on basis of twenty years' life—

	£
Cost of renewals due to breakages	24.12
Interest at 4 per cent. per annum on first cost	41.80
Annual reserve ditto after twenty years' life	17.40
Net cost of sleeper	83.20

Annual cost on basis of twenty-five years' life—

	£
Cost of renewals due to breakage	19.3
Interest at 4 per cent. per annum on first cost	41.80
Annual reserve ditto after twenty years' life	12.5
Net cost of sleeper	73.60

Annual cost on basis of thirty years' life—

	£
Cost of renewals due to breakage	16.08
Interest at 4 per cent. per annum on first cost	41.80
Annual reserve ditto after thirty years' life	9.65
Net cost of sleeper	67.53

Summary:—

	£
Wooden sleepers, at 7*s.* each, with cast-iron chairs, 3.11 sq. ft. bearing area and twelve years' life, cost per annum	127.3
Wooden sleepers at 5*s.* each ditto ditto	100.09
Cast-iron pedestal sleepers, with wrought-iron tie-bars, 2.75 sq. ft. bearing area and thirty years' life, cost per annum	109.5
Ferro-concrete sleepers with wrought-iron chairs and tie-bars, 3.9 sq. ft. bearing area and twenty years' life, cost per annum	97.07
Ditto ditto, and 30 years' life, ditto	79.8

In conclusion, it must be pointed out that the cost of the permanent way is not the only factor which must be taken into consideration, a bad running road entails increased cost in haulage and upkeep of rolling-stock, apart from the question of the comfort of the passengers. Special attention may therefore be called to the remarks, given herein, made by Mr. Derry, the permanent-way inspector in charge.

THE SCIOTOVILLE BRIDGE.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(*Continued from page* 83.)

Connection at U–14.—At the point U–14 it was necessary to bend the top chords downward and bend the bottom chords upward in order to engage the tops of the vertical posts. This was accomplished by means of a special yoke enclosing and connecting the vertical posts and top chords shown in Fig. 10, on Plate XVIII. A pair of transverse plate girders enclosing the upper part of the vertical posts were fastened to it with service bolts, through open field rivet holes. The cantilever ends of these girders were connected by double longitudinal vertical diaphragms with clearance between them to receive vertical tension bolts, 3¼ in. in diameter, the upper ends of which passed between a pair of transverse girders above the top chord. Two 200-ton hydraulic jacks were seated under the upper transverse girders bearing against them and against the top chord, and their operation deflected the chord downward, elongated the vertical post and deflected the bottom chord upward until the open field rivet holes through the connection plates in the vertical post and top chords registered, and sufficient drift pins and service bolts

were put in the connection to hold it securely until finally riveted.

Assembling the Bridge Members.—As the floor was finished, two standard-gauge service tracks were installed on it and were connected at both ends with cross-over switches, as shown in Fig. 6, on Plate VIII, published in our issue of January 25. On these tracks the members were brought out on flat cars usually pushed by locomotive cranes that unloaded the lighter members, such as the vertical portion of the U-beams and bracings. Both tracks were used simultaneously, and the materials were delivered on each for assembling in its adjacent truss.

The gantry traveller commenced the erection of the floor beams before it was built up to the full height. The upper transverse girders were temporarily connected to the vertical posts about 90 ft. below their final elevation. This made the traveller very much lighter and reduced the length of the tackles so that erection operations were simpler and more rapid. Subsequently, during the erection of the Ohio span, a guyed derrick was installed on a temporary floor and was used to complete the erection of the traveller, carrying it up to its full height necessary for handling and clearing the top chords.

Handling Truss Members.—The storage yard on shore at the end of the bridge, where material was piled on skids awaiting its erection, differed from the storage provided for some other recent bridges in that, instead of being equipped with a travelling crane, it was served by a pair of locomotive cranes that proved very convenient and flexible and obviated the necessity of switching engines to haul the steel to the bridge traveller. A view of a pair of these cranes revolving the inclined web-member M–19—U–18 is shown in Fig. 11, Plate XVIII.

Great care was taken to deliver the bridge members on the bridge in exactly the proper position, right side up and right end front, with as many loose pieces bolted to them and as much preliminary riveting done as possible on shore to reduce the amount of work aloft. Chord pieces and other members were rolled over on skids when necessary by 1¼-in. steel rope slings, bearing against wooden blocks clamped to the flanges, and having their bights supported on sheaves suspended from the hoisting tackle on the booms of the locomotive crane. The turning was done by means of a runner line operated on a hoisting-engine spool.

Most of the pieces were handled by special lifting yokes, consisting of two double channels with a pin through the centre of their webs, that carried a sheave engaging the bight of the sling that supported the member. Two yokes were connected to each two-panel chord section and one yoke at the centre of gravity of all other main members. Another hitch, made of plates, was usually provided at the upper ends of the diagonals.

Occasionally special connections were used for special pieces, as was the case of the L–20 bottom chord section near the centre pier, which weighs 44 tons, and was handled by a heavy wire rope sling, the loop end of which engaged pins in two large clevices attached to the 13-part tackles by which it was handled. A view of this arrangement is shown in Fig. 12, Plate XVIII.

In another case where the 80-ton trusses of the deck span, 152 ft. 6 in. long, were lifted as a unit, they were handled at one end by the 13-part tackle of a derrick car and at the other end by a balance beam supported by two 13-part tackles from the hoisting tower. Both balance beam and derrick car hoist were connected to the top chord of the truss by several parts of wire rope engaging wooden bearing blocks on the side of the chord and having their ends shackled to the hoisting tackles. A view showing this operation is given in Fig. 13, Plate XVIII.

The corresponding members of both trusses were usually delivered simultaneously to the traveller, and the heaviest ones, like the top chords of more than 60 tons weight, were hoisted by two 13-part tackles attached to them, as already described. The corresponding tackles at both ends of both pieces were drawn towards each other (out of vertical planes) by endless double auxiliary cables called "fleeting-falls," passing through special double snatch blocks that were connected to the main tackles. The fleeting-falls were used until the members were hoisted above the tops of the vertical posts. The fleeting-falls were then slacked off allowing the hoisting tackle to swing into the vertical planes of the trusses and the pieces were lowered to the required position for their final connection. Fig. 14, Plate XVIII, shows the operation above described.

Passenger Elevator.—Greater safety for the bridge erectors was secured, their efficiency was increased, and a valuable saving of time was effected by the installation, at the centre pier, of a temporary passenger elevator to hoist the men from the bridge floor to the top chord, about 130 ft. above. The elevator, which is seen in Fig. 15, Plate XVIII, was very simple in construction, consisting of a pair of cantilever plate girders fulcrumed on the top chord of one of the trusses and carrying, outside of it, a small timber tower from which was suspended a wooden car, hoisted by a two-part cable operated by a hoisting engine. This elevator saved the men considerable exertion in climbing to the upper part of the bridge, and was also very convenient for the transportation of kegs of rivets, tools and any other small articles. A stairway was afterwards built on one of the inclined posts of the Ohio span.

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE annual general meeting of the above Institution was held on Friday last, the 15th inst., at the Institution of Civil Engineers, Great George-street, Westminster, at 6 o'clock p.m., the president, Mr. Michael Longridge, occupying the chair.

THE LATE SIR J. WOLFE WOLFE-BARRY.

The president referred to the fact that by the death of Sir John Wolfe-Barry the Institution had lost, since the last meeting, another member of council. Sir John was well known to all members, who would also be familiar with the great work he had done. Perhaps his greatest achievement on behalf of mechanical engineers was the inauguration of the Engineering Standards Committee, coupled with his great influence in holding that committee together and reconciling all sorts of conflicting interests. The results of this work would live for many years, and would, the speaker believed, be adhered to by many Continental nations and in America. The council had agreed that he (the president) should write a letter of condolence to the widow and family of the deceased.

The minutes of the previous meeting having been read, the secretary announced that eight transferences from the class of associate member to that of full member had been made by the council.

ANNUAL REPORT.

The annual report of the council for the year 1917 was next presented. Of this report the following is a summary:—

The changes which have taken place in the roll during 1917 are the following:—additions: Members, 118; associate members, 254; associates, 3; graduates, 39; total, 414. The deductions are: Members, 86; associate members, 153; associates, 5; graduates, 111; total, 355. On December 31, 1917 there were 6,306 names on the roll.

His Majesty the King has conferred the following honours upon members:—

Baronetcy.—Sir Robert A. Hadfield, D.Sc., D.Met., F.R.S. (vice-president).

Knights Commander of the Order of the British Empire.—Mr. George J. Carter; Dr. Dugald Clerk, F.R.S. (vice-president); Sir Vincent L. Raven (member of council).

Knights Bachelor.—Mr. John A. F. Aspinall, M.Eng. (past-president); Mr. George T. Buckham; Mr. Vincent L. Raven; Mr. William Weir.

Commanders of the Order of the British Empire.—Mr. William Blane; Mr. Alan E. L. Chorlton; Mr. Henry Fowler, Sir G. Croydon Marks, M.P.

Companions of the Order of St. Michael and St. George.—Hon. Lieut.-Col. John D. Cormack, D.Sc.; Major Bertram Hopkinson, F.R.S.; Mr. Francis E. Kanthack; Lieut.-Col. Nathaniel Wilson, D.S.O., R.E.

Officers of the Order of the British Empire.—Mr. George Cuming; Mr. William J. Larke; Mr. Ernest Parkinson.

Companion of Honour.—Professor William Ripper, D.Eng., D.Sc.

Distinguished Service Order.—Major J. H. Dobson, S. African Pioneers; Captain N. L. Inkson, I.A.R.O.; Major B. C. L. Jervis, R.E.; Lieut.-Col. D. S. Kennedy, A.S.C.; Lieut.-Col. J. A. Methuen, K.R.R.; Major L. C. Miller, R.G.A.; Major W. H. Morgan, R.E.; Major F. G. Payne, M.G.C.; Lieut.-Col. George Rollo, Junr., K. Liverpool Regt.

Members of the Order of the British Empire.—Mr. Henry Moss; Mr. Herbert Schofield.

Military Cross.—Lieut. A. H. Atkins, R.G.A.; 2nd Lieut. C. F. Budenberg, L.D.E.; 2nd Lieut. Ian R. Cartwright, R.W.F.; Lieut. C. H. Goulden, R.E.; Lieut. H. Y. V. Jackson, R.E.; Lieut. A. R. Mangnall, R.E.; 2nd Lieut. T. S. Riley, A.S.C.; Lieut. A. J. Skinner, R.E.; Hon. Captain R. Stevenson, A.O.D., I.O.M.; Hon. Captain C. F. D. Suggate, A.O.D., I.O.M.; Captain H. R. Tupper, A.S.C.; Captain F. L. Watson, 7th W. Yorks. Regt.

Commandant Paul L. Roux has been created a Chevalier of the Legion of Honour; and Captain John Donnelly (E.A.F.) and Lieut.-Col. H. C. Sparks, D.S.O., have received the French Military Cross.

The accounts for the year ended December 31, 1917, have been duly certified by the auditor. The total revenue was 22,865*l.* 12*s.* 9*d.*, while the expenditure was 22,701*l.* 1*s.* 7*d.* (including 9,943*l.* 2*s.* 2*d.* invested for reserve funds), leaving a balance of revenue over expenditure of 164*l.* 11*s.* 2*d.*

The former "Sinking Fund for the Redemption of Debentures and the Institution's Leasehold Property" has been superseded by four separate reserve funds, namely, the Debenture Redemption Sinking Fund, the Leaseholds Amortisation Sinking Fund, the Staff Pensions Fund, and the General Reserve Fund. The various securities have been entered at their market value as on May 18, 1917, the date when the new funds were instituted by the council.

The total assets of the Institution amount to 144,319*l.* 3*s.* 8*d.* Deducting therefrom the 34,025*l.* of debentures, 5,000*l.*, the balance of Messrs. R. and R. Williamson's loan, other small liabilities, and 37,049*l.* 15*s.* 1*d.*, the sum of the four reserve funds, there remains a net credit balance of 66,503*l.* 9*s.* 2*d.*

The Institution House being still occupied by H.M. Government, the general meetings have been held in the theatre of the Institution of Civil Engineers, for the use of which as well as the reading room and library the council again desire to record their indebtedness and tender their hearty thanks.

The names of over 1,000 members have now been received as being, or having been, on active service, many from the commencement of the war; and the council regret that during the past year 22 have lost their lives in various parts of the world. Nine members of the Institution staff have now joined the forces, one of whom has died from wounds.

With a view to helping those still on active service, and other members engaged on war work, to find suitable employment on their return to civil life, the council have prepared and issued to them, so far as their addresses are known, forms whereon they may record such particulars of their training and experience as will enable the secretary to answer inquiries likely to bring together those offering and those seeking positions in engineering works or offices. So far about 100 of these have been filled in and returned, and are now being analysed and tabulated for future use. It is almost unnecessary, though perhaps better, to add that all information given in this way will be treated as confidential, and will only be used for the benefit of the giver.

The Thomas Hawksley gold medal for 1918, given annually for the best paper published in the Proceedings of the preceding year, has been awarded to Mr. A. A. Griffith, M.Eng., and Mr. G. I. Taylor, M.A., for their paper on "The use of Soap Films in solving Torsion Problems."

Grants were made by the council, for the year, in aid of the four researches now being carried on under the direction of the Institution, namely:—

	£
Alloys	250
Steam-Nozzles	100
Hardness Tests	100
Wire Ropes	450

The following paragraphs describe briefly the work done by these various Research Committees:—

Alloys Research.—The committee has been occupied with investigations on various light ternary alloys. These have been conducted at the National Physical Laboratory with the assistance of the Department of Scientific and Industrial Research from whom the committee received a grant of 400*l.* in addition to a sum of 800*l.* paid directly to the laboratory for the provision of special plant. The committee's eleventh report, which would have contained the result of these investigations, has been temporarily withheld in the public interest.

Steam-Nozzles.—The committee has been so fully occupied on war work that it has been impossible to construct apparatus and to carry out tests; but complete detailed working drawings of the apparatus for measuring the impulse of steam jets have been prepared, and it is hoped that this apparatus may shortly be put in hand, and such progress made as present circumstances permit.

Hardness Tests.—Dr. Stanton, with his special machine at the National Physical Laboratory, has continued the series of tests for the committee, with special reference to the effects of variations of load and speed on rate of wear. A series of wear rings has been made of varying widths, from material supplied by Sir Robert Hadfield, who has also undertaken their hardening. Another holder of these rings has been constructed of a form which will considerably facilitate regrinding. A series

of specimens have been prepared and the tests are now in hand. The work has been delayed for a few months owing to some of the apparatus being required for urgent war work. In addition to the Institution's grant, a sum of 100*l.* has been received from the Department of Scientific and Industrial Research.

Arising out of the discussion on the Report of the Hardness Tests Research Committee, Sir Robert A. Hadfield, Bart., vice-president, placed in the hands of the Institution a sum of 200*l.* to be awarded, under certain conditions as a prize or prizes for the description of a new and accurate method of determining the hardness of metals, especially metals of a high degree of hardness. The council regret that as yet few such descriptions have been received.

Wire Ropes.—The work of the committee has been again much delayed by preoccupation of its members with war work, also by the prolonged illness of the chairman. Nevertheless a design for a testing machine has been approved in principle, for giving a somewhat wider range of tests, in the direction of providing for more bends, both simple and reverse, than originally contemplated, also for bends in planes at right angles. The choice of a site for its erection has been deferred, as the research is not considered necessary for the prosecution of the war.

In response to the announcements, in the Institution Journal for December, 1916, and January, 1917, of the offer from Mr. Richard Williamson of a gift of 500*l.* in aid of engineering research, and to the invitation to members of the Institution to suggest suitable subjects for such research, a number of suggestions were received. The council, acting on behalf of Mr. Richard Williamson and his brother, have selected the following as being suitable: A research to determine the best form and material for piston and piston rings, especially for internal-combustion engines; and now await the approval of the Department of Scientific and Industrial Research, through whom Mr. Williamson's offer was transmitted to the Institution.

An offer of 500*l.* from Mr. T. Bernard Hall has been gratefully accepted to found a prize fund for papers submitted to the Institution, dealing with invention, design, or research in mechanical engineering.

A grant of 50*l.* was made in March towards the work of the recently constituted Conjoint Board of Scientific Societies, and representatives of the Institution have given evidence before the board on the subject of engineering education.

A representative meeting of engineers and others interested in the professional training of engineers was held at the Institution of Civil Engineers in October, when a resolution was passed expressing the opinion that some form of central organisation was necessary for the purpose of co-ordinating the scholastic with the workshop and office training of engineers. A committee representative of the principal engineering and educational bodies was appointed to give effect to this resolution.

During the year the council received information that offers were being made in Australia on behalf of American engineering firms to take and train apprentices on very advantageous terms, including a liberal living wage during the period of apprenticeship. These offers have received the attention of the council as likely to have far-reaching consequences, but no formal action has been taken because the council found that the B.E.A. (the British Engineers Association), a representative body of manufacturing engineers, was dealing with the matter, and it was thought that this body could deal with it more effectively than the Institution. The matter was brought to the notice of the members in the January Journal, 1918, but it is mentioned here again on account of its interest and importance.

The Institution examinations were held in October. Thirteen candidates passed the graduateship and 15 the associate membership examination. On the results of the associate membership examination, a prize of the value of 5*l.* was awarded to C. T. Glass-Hooper, while J. K. Greening (*G.*) and R. Hedley (*G.*) received honourable mention. A prize of the value of 3*l.* was also awarded to A. L. Williams, on the results of the graduateship examination. The next examinations will be held in October, 1918.

The Advisory Committees for India and South Africa which were constituted in 1916, have continued to act during the year, and the council desire to acknowledge with grateful thanks the assistance thus rendered. A similar committee is being constituted in Australia.

The Graduates' Meetings were again suspended during the year, but facilities have been kindly afforded by which Graduates have been enabled to attend the Sessional Meetings of the Engineering Societies of the Universities of Bristol, Edinburgh, Glasgow, Manchester, and Armstrong College, Newcastle-on-Tyne.

Benevolent Fund.—The Benevolent Fund has made grants to several members and dependends of members of the Institution. Ninety-eight life members have made donations of ten guineas and upward, and 204 ordinary members are annual subscribers of not less than half a guinea. It is to be much regretted that a large number of members of the Institution have not yet subscribed.

Mr. Daniel Adamson seconded the adoption of this report—moved by the president—and remarked that the thanks of the Institution were due to the Finance Committee for the trouble they had taken in altering the form of the revenue account. In relation to the Australian offer to take and train American apprentices, he would urge the Institution not to lose sight of this matter, inasmuch as the British Engineering Association, who had the question in hand, might not regard it as important. He also thought that the thanks of the Institution should be accorded to Mr. Pitt for his work in connection with the Wire Ropes Committee. In regard to the benevolent fund, the speaker emphasised the small cost of management as compared with other funds of this nature, and, bearing in mind the objects for which the benevolent fund had been established, he strongly supported the appeal made by the president for additional subscriptions. The report was then unanimously adopted by the meeting.

AWARDS AND PRIZES.

The secretary announced that the winners of the Thomas Hawksley gold medal, founded in 1914, were as follow: Mr. R. S. Whipple (1914); Professor E. Sauvage and the late M. Anatole Mallet (1915); Professor H. L. Callendar, F.R.S. (1916); Mr. Daniel Adamson (1917); and Mr. A. A. Griffith and Mr. G. I. Taylor (1918). Owing to the difficulty of obtaining gold, the medals presented were struck in bronze, to be replaced later by gold medals. Presentations, accompanied by a few appropriate remarks, were made by the president in the cases of Mr. R. S. Whipple and Mr. D. Adamson, the only winners present. The president also handed an award of the value of 5*l.* to Mr. C. T. Glass-Hooper, this award having been granted on the results of the associate membership examination, while a prize of the value of 3*l.* was handed to Mr. A. L. Williams, in connection with his graduateship examination.

The secretary further announced that out of the sum of 200*l.* given by Sir Robert Hadfield as the foundation of a prize for a new method of determining the hardness of metals, 25*l.* had been awarded to Professor C. A. Edwards, D.Sc., and Mr. Frederick W. Willis, B.Sc., for research work in connection with the law governing resistance to penetration of metals capable of plastic deformation and a new hardness scale in fundamental units.

ELECTION OF OFFICERS.

The secretary state that the ballot list for the election of officers had been opened by a Committee of the Council, and the following had been found to be duly elected:—As president: Mr. Michael Longridge. As vice-presidents: Messrs. Wm. H. Allen and J. Rossiter Hoyle. As members of council: Mr. Daniel Adamson, Sir Henry Fowler, K.B.E., Dr. Edward Hopkinson, Mr. H. A. Ivatt, Engineer Vice-Admiral Sir Henry Oram, K.C.B., Messrs. James W. Restler and Mr. Richard Williamson.

TRACTION ON BAD ROADS OR LAND AND TILLAGE TRACTION.

It will be remembered that at the previous meeting two papers were read, one entitled "Utility of Motor Tractors for Tillage Purposes,"* by Mr. Arthur Amos, and the other "Traction on Bad Roads or Land,"† by Mr. L. A. Legros, the discussion on the two papers being deferred until the meeting on Friday last.

Mr. H. G. Burford was the first speaker. He opened by thanking Mr. Legros for his excellent historical review of road traction, the subject being divided into two parts, one on wheel traction and the other on the development of traction by means of caterpillar or chain wheels. The general questions had been dealt with before both the Institution of Mechanical Engineers and the Institution of Automobile Engineers many times, but a feature of interest to the speaker was the four-wheel drive, which, from the commercial standpoint, had been rapidly developed since this country had engaged in war. In his opinion, however, the commercial utility of the four-wheel drive was limited in such countries as our own, but in new countries, where the roads were not good, there was a large field for this type of drive. From his own experience, he entirely supported the building of commercial vehicle on the unit principle, the engine and transmission being one unit, others being the rear axle and differential, the frame and springs, front axle and steering. Each unit being self-contained, low cost of operation would result. The great question, from the commercial point of view was interchangeability. In regard to the differential locking gear, the speaker had not found, in his 18 years' experience, that the various designs he had studied had proved of much use in practice. With the ordinary back-wheel drive, when one wheel was locked, if a vehicle got into difficulties which it could not overcome with one wheel, the matter became hopeless. A point which had been discussed, both in this country and in America, was the final drive or final form of transmission. There were, apparently, two heads of discussion, (1) the worm drive and (2) the internal pinion or rack and pinion. The development and steady progress of the internal gear-driven machine in America had been remarkable, and he, personally, had always strongly advocated the rack and pinion as against the worm drive as used in this country. On the question of braking, the author had suggested the possibility of using brakes on all four wheels, instead of only on the two rear wheels, as in ordinary practice. The question was mainly one of speed and judgment, and with the general improvement in motor driving in this country, he thought that, in the case of the commercial vehicle, present braking practice sufficed.

The speaker regarded the second part of the paper as the more interesting, setting out, as it did, the details of the various forms of caterpillar, chain track, pedrail and other types. If the author would present a paper in which the experience of manufacturing engineers could be incorporated, and in which the reasons for the obsolescence of certain types of tractors could be set forth, it would be of great value. It would then be understood on what grounds—whether cost of manufacture, inaccessibility, or some other ground—certain vehicles had been discarded.

Colonel Crompton, C.B., who followed, explained that he had been partly responsible for Mr. Legros' paper, as he had been working with Mr. Legros on a matter of national importance connected with the subject. Some thirty-six years ago he had read a paper, before the Royal Institution, on Thomson's Road Engines as used in India for travelling over soft ground. Owing, however, to the opposition of the railway people, the potentialities of road traction were neglected. It was now seen how necessary it was that railway systems should be supplemented by systems of road carriage, for the development of farming interests. Colonel Crompton then proceeded to indicate how far the inventions of R. W. Thomson foreshadowed, in many details, the developments referred to in the paper. In that connection, he might mention that Sir Alex. Kennedy, Mr. Richard Muirhead and himself were probably the only people alive who had had the privilege of conversations with R. W. Thomson, and had discussed the weak points and difficult points of the latter's inventions. The Boydell girdle, now used for the support of guns, the various forms of chains encircling the wheels, &c., all had been foreseen by Thomson's mechanical genius. Thomson produced a flat foot with the aid of a thick rubber tyre, giving practically an endless chain with an infinity of pin points within the rubber itself. Unfortunately, internal wear of the rubber took place, a kind of hysteresis. This trouble existed at the present time in the case of motor-bus tyres and the like, and a committee had been appointed to deal with such matters after the war. By an enormous expense of rubber, the flat foot was obtained, but wear took place externally and internally, the latter largely through slipping of the wheel. The attempt to introduce a sort of friction clutch, to take the place of the differential, was abandoned on the score of expense. In conclusion, Colonel Crompton desired to emphasise the fact that there had never been a time when engineers could address themselves with greater advantage to the design and construction of a thoroughly efficient tractor to go on the farmer's land, bring away the produce, and carry it to the market. He would be doing justice to Mr. Burford if he said that one of the most beautiful pieces of design of the kind he referred to was that of Mr. White, the inventor of the "White" steam car. He had examined Mr. White's ploughing tractor—mentioned in the author's paper; and if, in the combination of simplicity and brilliant ideas, the other

* See ENGINEERING, page 86 *ante*.
† See ENGINEERING, page 103 *ante*.

tractors named by Mr. Legros resembled this ploughing tractor they were well worthy of study by engineers.

Mr. George Watson said that Mr. Legros had not mentioned the steam tractor, and in this relation the speaker referred to Clarkson's coke-fired "steamers" as likely to be heard of in the future. Reference had been made in the paper to the "nut-cracker" action of the caterpillar mechanism when clay got into the interstices. This the speaker regarded as a principal difficulty with tractors on land or off the road. Even when stones did not actually get into the gearing, the wear and tear on the latter was very great. Mr. Watson was greatly interested in agricultural traction, and therefore in the important contribution by Mr. Amos. He disagreed with the view of Mr. Amos that there were certain states of heavy clay land when, owing to hardness, it became impracticable for the tractor to deal with it. The speaker had seen a tractor ploughing 7 in. deep on clay land which had baked very hard, had been undisturbed for several years, was full of clover roots, and trodden down by stock. This tractor ploughed half an acre an hour with 3½ gals. of paraffin, working two furrows. The speaker was of opinion that there was a certain "most advantageous" speed of plough. Mr. Amos had given the figure of 2 miles an hour for the horse plough and 3½ miles for the motor plough. Mr. Watson believed, however, that 2½ miles an hour for a motor plough would be found quite fast enough, and attempts to work too quickly would result in using the power of the engine less efficiently. Moreover, very rapid ploughing broke up the furrows and left the work in an untidy state. One point of importance in the design of agricultural tractors that might have been mentioned by Mr. Amos, was the question of the subsoil; there was a great deal of land which would benefit immensely by having its subsoil broken up below the surface of the ploughing. It was, however, important that it should not be brought to the top, and deep ploughing would not meet the case. Subsoiling with a coulter of some sort underneath the main plough would be a matter of great importance, given the power of the motor to draw the machine.

Mr. W. H. Patchell referred to a point brought out by a speaker at the meeting in Lincoln at which Mr. Legros had also read his paper. That speaker, who had come from East Africa, stated that he had been severely taxed by the difference in track in the case of certain motors. For this reason, among others, Mr. Patchell agreed with Mr. Burford in thinking that there should be some sort of standardisation of track. In regard to the work done by agricultural tractors, Mr. Watson had mentioned half an acre an hour, and the speaker would supplement that by referring to a ploughing tractor unit which, in Hereford, the week before last, had achieved a record, the average work done per tractor per week being just upon 30 acres. This was a great advance upon the acre a day ordinarily accomplished by one man. With regard to unsuitability of the tractor to the land, he had known cases in which the track of the tractor could be plainly seen in the following year's crops; these cases were in South Lincolnshire and North Cambridgeshire. Mr. Patchell had had, in his apprenticeship days, to make and repair some of the Thompson machines, with rubber tyres ranging in width up to 15 in. and in thickness up to 5 in.

Major E. G. Beaumont was the next speaker. He referred to the type of differential gear illustrated by Figures 5 and 6 in Mr. Legros' paper. Mr. Legros had stated that in the use of the Walter automatic-locking differentials the third differential on the main shaft could be dispensed with. He gathered from the paragraph containing that statement that the third differential could be dispensed with not on account of the four-wheel drive or four-wheel steering, but on account of the use of the worm type of differential. With this type of differential it was easy to understand that although one wheel on an axle might be off the road or slipping, the full torque might be delivered to the wheel that was on the road. The speaker could, however, see that the two wheels on one axle might together have a higher velocity than the pair of wheels on the other axle. Therefore a differential gear would still be required if differences of average velocity were to be provided for, as when a four-wheel drive and two-wheel steering machine traversed a curve or when there was a difference in diameter of the wheels, such as might arise from one tyre being partially worn and the other being new. The cases of the Jeffery and Walker quads, employing two differentials, were interesting, because, for a given radius on a curved path, the inequality of the differential joint giving motion to the wheel-driving shafts, was much less than would otherwise be the case. The use of the four-wheel steering arrangement did apparently diminish the severity of the work on the universal joints; and, in the speaker's opinion, assisted in dispensing with the third differential gear by limiting the difference in average velocity of the two axles, on account of the inclination given to the steering wheels. While not claiming more than a limited experience of the four-wheel drive vehicles, he had seen the Jeffery and the four-wheel drive in action, and knew that in the case of the Jeffery, with two differentials, wear and tear on the driving joints, and other parts bearing stresses in transmission, was not so rapid as in the cases in which three sets of differentials were used. Perhaps Mr. Legros would explain this statement further.

Mr. P. M. Baker considered that on a four-wheel drive vehicle electrical drive offered great advantages as compared with the case of a two-wheel drive-vehicle; the fact that it was practicable to make electricity take the place of the differential

COAL-DISCHARGING MACHINERY.

CONSTRUCTED BY MESSRS. ED. BENNIS AND CO., LTD., LITTLE HULTON, BOLTON.

(*For Description, see opposite Page.*)

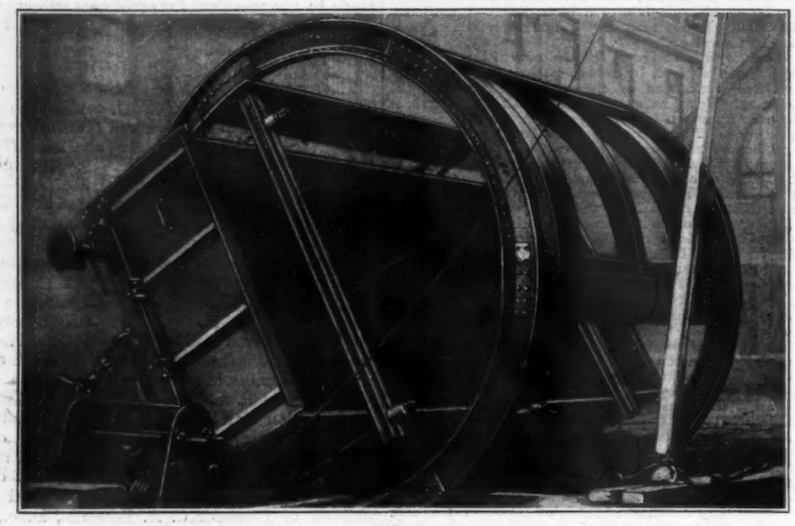
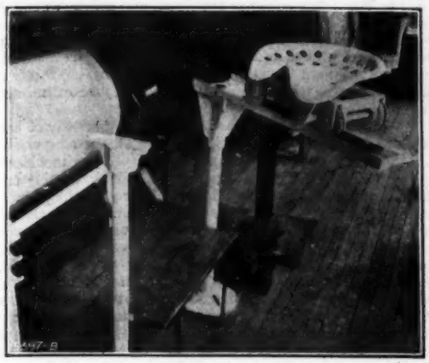


Fig. 1.

Fig. 2.

THE MARSHALL CHAIR FOR CRIPPLED WORKERS.



and universal joints, thus doing away with very awkward driving conditions, gave electrical drive for a four-wheel driven vehicle a very strong claim. In relation to the chain-track tractor, it seemed to him that the provision of steering gear with a sector and screw, to adjust the pressure on the ground surface, added another worry for the steersman. He would suggest the use of a pneumatic cylinder, with a progressive blow off, or a similar arrangement, to avoid the necessity of complicating the work of the driver. Perhaps Mr. Legros would explain how far the method of steering by means of chain tracks was successful, and might eventuate in the disappearance of the steering wheel.

Mr. L. A. Legros then replied to the discussion. Dealing first with the design of commercial vehicles he entirely agreed with Mr. Burford as to the adoption of the unit principle of construction, subject, however, to the provision of easily operated and readily accessible means of connecting the different units together. The engine must be easily removable from the frame without entailing material damage to the rest of the machinery. The gear box should be able to be taken out by itself, without stripping axles or engine, and the same conditions should apply to the front and rear axles, which also, accompanied by their brake gear, or certain parts of that gear, should be removable as units.

He (the speaker) had alluded to the final transmission in his paper before the Institution of Automobile Engineers. One of the American types shown had internal racks and front-wheel brakes. These, however, he did not regard as either necessary or valuable, excepting so far as they made the front and back of the vehicle the same.

With regard to the question raised as to the means of control in tractors, control was easily effected by clutches and brakes. He recognised the advantage of giving the causes of obsolescence, and had done so in some cases—types which had come and gone. He had felt, however, that it would be unwise to emphasize the causes of failures of recent date.

All the makers of tractors were contending with the picking up of stones and dirt by continual improvements in the chain. The point of first importance in regard to all the chains was the question of their being clear of the ground. The figures in his paper were all calculated on the protection of the chain, for so much of its length as would be covered, to a depth of 2½ in. to 3 in.

With regard to speed, he had shown an American plough that worked at 2½ miles an hour. He could not give the insistent weight, but he could say that the amount ploughed per day was about 20 acres, the power being 45 h.p. This was done by increasing the number of ploughshares rather than the speed of the ploughing. Major Beaumont was quite correct in saying that the third differential was not truly done away with by the M. and S. or the Walter differential. But the worm differential did not compensate for the inequality in the size of the front and back wheels, although it did take care of the matter of turning curves.

On the question of electric drive, this drive was, of course, easy to control, but it involved much complication. In the example he had shown there were eight bevel pinions and eight bevel wheels, whereas in the case of the differential there would only be six. To other points raised in the discussion, he would reply in writing.

The president then announced that the next meeting would be held on March 15, 1918, when a paper would be read on the employment of women in munition factories, and possibly another paper.

THE BENEVOLENT FUND.

The meeting above reported was followed by the sixth general meeting of the Benevolent Fund of the Institution. At this meeting only business of a purely formal nature was transacted, the Report of the Committee of Management for 1917 being unanimously adopted.

The proceedings were terminated by a vote of thanks being passed to the Institution of Civil Engineers for the use of their room.

APPLIANCES FOR DISCHARGING COAL FROM WAGONS.

MODERN industrial processes involve the use of coal in extremely large quantities, and this will undoubtedly continue to be the case in an ever-increasing degree for many years to come. Power is a large item of expense in most manufacturing works, and fuel represents about 70 per cent. of its total cost. The cost of coal has, during recent years, been steadily rising in price, and there is every reason to anticipate that it will continue its upward tendency. The cost of coal, however, in its relationship to the total cost of power, must not be regarded merely as the price paid per ton delivered to the works. To this must be added the cost of labour in handling until its final consumption in the furnace. In this latter respect there is still ample room for the introduction of modern machinery for effecting economies and increasing efficiency.

One method by which marked economy can be obtained is by the installation of truck-unloading plant. In this connection it may also be mentioned that an economic advantage of a reflex nature is thus secured, for the automatic discharge of railway trucks releases them for further use much more quickly than would otherwise be the case. The result of this is, in effect, to increase the carrying capacity of the railway by enabling a truck to perform two or three journeys instead of one.

The first truck tippler ever built in this country for dealing with standard railway trucks was made by Ed. Bennis and Co., Limited, for the Metropolitan Electric Supply Company's works at Acton-lane. It was installed in the year 1903, and after fifteen years of active service is still as good as ever, though many detail improvements have since been made. The truck tippler at this station forms part of a complete coal-handling equipment designed for handling small coal at the rate of from 60 tons to 80 tons per hour, and conveying it from the trucks to the boiler furnaces. In this system the loaded wagon, or coal truck, is turned over bodily, and its contents fall into a hopper built to receive it, and pass hence to a conveyor of the Bennis U-link type. Opposite the boiler-house are two main lines of railway, and a large coal bunker of 70 tons capacity has been built below the coaling lines. Immediately over the top of this bunker are mounted two of the Bennis rotary side-truck tipplers which enable the trucks to be completely turned over to be emptied. The tipplers are arranged so that the upper halves can be lifted off to allow a locomotive to pass through.

A very similar tippler at the Amsterdam Gas Works is shown in Fig. 1 on the opposite page. The wagon is secured in the tippler by clamps which, when tightened up, hold it perfectly in place. The clamps are provided with a strong compensating mechanism to take up any shock. When the wagon has been secured, the attendant, by means of a switch, sets a 5-h.p. electric motor in operation, which rotates the tippler containing the truck, the fuel being emptied into the receiving hopper, from which it is taken away by the conveyor. One specially interesting point to be noticed in the design of this tippler is that by its complete revolution it saves trimming, whilst emptying all the coal. It rests on a series of rollers, one side being actuated by a reversible electric motor. Each tippler is capable of emptying 100 tons of coal per hour.

Another point worthy of notice is that the tippler rings are so proportioned that their centres nearly coincide with the centre of gravity of the truck in end elevation. The advantage of this will be obvious, the power required to work the tippler being very little more than is sufficient to overcome the friction in turning.

The system of conveying may be described as consisting of a series of chains in troughs of special hard cast-iron. The cross conveyer is placed immediately beneath the bottom of the bunker which receives the coal. The coal passes to this cross-conveyer through shoots with adjustable cut-off slides, and, after being partly elevated, is delivered on to the main inclined elevator-conveyer. The fuel is then delivered on to the main distributing conveyer, which runs the full length of the overhead storage bunkers.

A somewhat similar plant, though on a much larger scale, is that recently erected to the order of H.M. Government. In this case the plant serves a range of 32 Lancashire boilers each fitted with "Bennis" mechanical stokers and compressed air furnaces. Storage is provided for about 2,240 tons of coal, and the coal is transferred from the railway trucks to the storage bunkers at the rate of 60 tons per hour, and the plant is capable of transferring the coal from the bunkers to the stokers at the rate of 1 ton per boiler per hour.

The full railway trucks are pushed by the locomotive into a "Bennis" rotary truck tippler which, as in the previous case, revolves through a complete circle so that the trucks are turned upside down and completely emptied without raking or trimming. The clamping gear which holds the trucks in position is adjustable, so that the tippler can take any height of truck up to the maximum size for which it is designed.

Another type of truck-discharge plant is that by which standard railway trucks are emptied by allowing the coal to flow by gravity through the end door of the truck. Fig. 2 shows one of these as supplied to Messrs. Coats and Son, Limited, Paisley.

The truck is run on to a platform, one end of which can be raised by a screw. The screw passes through a nut formed in the centre of a phosphor-bronze worm wheel, which is turned by a mild steel worm operated through spur-reduction gear from an electric motor. The worm wheel and worm are contained in an oil bath, which oscillates on trunnion bearings. The purpose of this oscillation is to allow the top of the screw to move sideways and follow the path of the platform, as it rises. About 5 brake horse-power is required to raise a full 10-ton truck, and the tippler can be arranged to drive by a belt from adjacent shafting, if electric power is not available.

SEATS FOR CRIPPLED WORKERS.

WE illustrate on this page a device which has just reached this country from Major Frank B. Gilbreth, E.R.C., of Providence, R.I., to assist the maimed, and especially those injured in this war. It is known as the "Marshall" chair, and is mounted on a track, pivoted at one end. A normal worker can stand or sit at will, and a one-legged or legless worker can sit down all the time and travel sideways, by pushing or pulling the chair in which he sits, from side to side.

To the workers at a loom, bench, press or table, who may have to move about when occupied by a task, the invention solves a problem. It will be noticed that the adjustable footrest can be moved to suit different lengths of leg, and that the swinging arm can be brought to the closed or open position in one motion.

It is also of great value as an eliminator of unnecessary fatigue, and its possibilities for enabling a one-legged or legless worker to undertake many jobs previously considered impossible for a cripple are obvious. It has been found that ordinary chairs mounted on wheels do not move sideways easily, and that the strain on certain organs caused by the occupier

of the chair trying to push such a chair when seated upon it, is apt to cause a certain painful malady.

We are indebted to Mr. James F. Butterworth, the British representative of Major Gilbreth, of 24, Linden Gardens, London, W., for these interesting photographs.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, dealing in *The Labour Gazette* with the labour market in January, states that in most of the principal industries employment was maintained at a high level, and the engineering, shipbuilding and iron and steel trades especially were working at great pressure. On the other hand, owing to restriction of consumption of raw materials, there was reduced working time in the textile group of trades.

Trade unions with a net membership of 1,038,547, excluding those serving with the Forces, reported 10,465 (or 1.0 per cent.) of their members as unemployed at the end of January, compared with 1.4 per cent. at the end of December and 0.3 per cent. at the end of January, 1917. The increase in unemployment as compared with a year ago was almost entirely due to the cotton industry.

Of the 3,662,673 male and female workpeople insured under the National Insurance Acts, 1911 to 1916, the number unemployed at the end of January was 32,063 (or 0.88 per cent.), compared with 0.81 per cent. in the previous month and 0.63 per cent. a year ago. For males and females separately the percentages unemployed at the end of January were 0.45 and 1.85.

Employment at coal mines was good in most districts; at collieries covered by the returns received the pits worked an average of 5.41 days per week in the fortnight ended January 26, as compared with 5.65 days per week in the corresponding period of 1917; the number of workpeople employed showed an increase of 1.5 per cent. compared with a year ago. At iron, lead and shale mines employment continued very good; at tin mines it was good. In quarrying, employment, though interrupted by bad weather, was fairly good on the whole.

In the pig iron industry employment was good; at iron and steel works it continued very good and a general shortage of labour was reported. The engineering and shipbuilding trades were extremely busy and much overtime continued to be worked. In the tinplate trade the restriction in the supply of steel bars was accentuated by the strike of bricklayers at steel works, and there were decreases in the numbers of tinplate and steel sheet mills in operation. In most of the other metal trades employment was good, and brass and sheet metal workers especially worked much overtime.

Employment in the cotton industry showed a decline in the weaving branch; in the spinning branch it continued moderate. There was also a slight decline, on the whole, in the woollen and worsted trades, the restrictions on the supplies of wool being increasingly felt. In the textile bleaching, printing and dyeing trades employment was fairly good. In the leather trades employment continued good on the whole; in saddle and harness making, however, it was only fair, and some short time was reported. Employment in the boot and shoe trade also continued good generally, though there was still some slackness with women workers owing to the shortage of skilled men.

Though private building work was restricted, Government requirements kept the men remaining in the brick and building trades well employed, and overtime was worked in some cases; cement workers were also busy, and overtime continued with a shortage of labour. Employment with mill sawyers and coopers was fairly good. In the printing trade employment continued good for those remaining in the trade, and much overtime was worked in London. In the paper and bookbinding trades it was also good, notwithstanding the scarcity of raw materials. In the glass trade some loss of time was reported through inability to complete "sets" of men owing to enlistments, but employment continued good; in the pottery trades it was also good.

In the first half of the month agricultural operations were hindered by unfavourable weather, but good progress was made later and arrears were made up. The shortage of permanent labour was largely met by the assistance rendered by soldiers and women.

With dock labourers employment was fair except at certain ports on the East Coast and in Ireland; with fishermen remaining in the industry it was fair on the whole.

The average weekly number of vacancies notified to all Employment Exchanges for the five weeks ending January, 11, 1918, was 32,799, as compared with 40,851 in the previous four weeks, and with 35,296 in the five weeks ending January 12, 1917. The average weekly number of vacancies filled for the same period was 24,282, 30,322 and 25,714 respectively. The numbers of workpeople remaining on the live registers at January 11, 1918, were 33,978 men, 58,046 women, 8,578 boys and 8,502 girls, a total of 109,104.

The increases in rates of wages (including bonuses) granted to take effect in January are estimated to have affected nearly 700,000 workpeople, and to have resulted in an aggregate addition of about 170,000*l.* on weekly rates of wages. These figures are exclusive of certain increases and bonuses which were arranged during January to operate from earlier dates. If such increases are included, the total number of workpeople affected is estimated at considerably over 1,000,000.

The principal changes affected various classes of munition workers; shiftworkers at blastfurnaces; workpeople in the carting industry in England and Wales; and operatives in the linen industry in Ireland. A large number of increases also took effect in the rates of wages of workpeople in the building and printing industries.

The number of disputes beginning in January was 98, and the total number of workpeople involved in all disputes in progress was about 93,000, as compared with nearly 77,000 in the previous month, and 6,800 in January, 1917. The estimated total aggregate duration of all disputes during the month was 533,000 days, as compared with 258,000 days in December, 1917, and 24,500 days in January, 1917.

Recent decisions given by the Committee on Production and the Special Arbitration Tribunal on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given, cover: Sheet metal workers, Coventry, motor works: (1) Piece work prices for motor work which were fixed prior to the outbreak of war, or which have subsequently been fixed on the basis of pre-war prices shall be increased 20 per cent. in addition to the 10 per cent which has already been added to these prices. (2) A Price Adjustment Committee to be set up to consider and adjust all piece work prices which appear to require reconsideration and adjustment. (3) All restrictions or limits on production to be abandoned. Motor drivers, Mersey Shiprepairers' Federation and Port of Liverpool Employers' Federation: The men concerned are plain time workers engaged on munition work, and are to receive a bonus of 12½ per cent. as from October 12, 1917. Building trades, Tyne and Blyth and Teeside and Hartlepool districts: The standard rate of wages for bricklayers, carpenters and joiners, plasterers and woodcutting machinists and stonemasons concerned shall be 1*s.* 2*d.* per hour (stonemason fixers, 1*s.* 2½*d.* per hour), and labourers 11*d.* per hour, as from the 11th inst., and in addition, the men are to receive a bonus of 12½ per cent. on earnings as from the first pay in January, 1918. The British Insulated and Helsby Cables, Limited: The men concerned aged 21 years and over and paid as plain time workers are to receive a bonus of 12½ per cent. on earnings as from first pay in January, 1918; piece workers and others on systems of payment by results, a bonus of 7½ per cent. on earnings as from the same date. Other decisions of the same nature apply to moulders in Doncaster, mechanics and moulders in Birmingham, etc.

The Building Trades Central Advisory Committee (Operatives) who advise and assist the Ministry of Labour on questions arising in the administration of Employment Exchanges which affect workpeople in building trades, held their eleventh meeting on the 13th inst. The committee discussed, among other matters, a statement by the department with regard to the responsibility for the fares and lost time of men who failed to secure engagement after being sent to take up a job at a distance, and also the best method of adequately protecting the department against the wrongful inclusion of payments in respect of trade disputes in a claim under Section 106 of the National Insurance (Unemployment) Act, 1911.

The Minister of Reconstruction, Dr. Addison, has appointed a committee with the following terms of reference: "In view of the probable extension and development of trade organisations and combinations, to consider and report what action, if any, may be necessary to safeguard the public interest." Mr. John Hilton, of the Garton Foundation, will act as secretary of the committee. To him at 33, Dean's Yard, Westminster, should be sent all communications.

The Ministry of Labour issued on the 15th inst. a notice of which the following is an abstract:—

"Although the time for the demobilisation of His Majesty's Forces is not yet in sight, the Government think it should be known that the problem has been receiving close attention.

"The Reconstruction Committee appointed by the late Government to consider plans for the ultimate demobilisation of the forces has presented to the War Cabinet a carefully considered scheme for effecting the discharge and the resettlement in civil life of the members of the forces. The responsibility for carrying out demobilisation will rest with the Admiralty and the War Office so far as the naval and military arrangements are concerned, and with the Ministry of Labour as regards the resettlement of discharged sailors and soldiers in civil life. When a lasting peace has been assured, men must be released from the forces in accordance with civil rather than naval or military requirements.

"In order to help the sailors and soldiers to get back into civil life as quickly and as easily as possible, the Ministry of Labour propose to use the machinery of the Employment Exchanges, which is the only national organisation sufficiently strong for the purpose, but in order to assist the Ministry and the exchanges the Minister of Labour proposes to invite the employers' associations and trade unions to give him the fullest possible assistance both centrally and locally. A central Committee, the 'Labour Resettlement Committee,' has been set up, consisting of representatives of the employers and trade unions in the principal industries in equal numbers, together with representatives of the departments concerned with demobilisation. The Minister of Labour will be chairman of the committee, and he has appointed Lord Burnham to be vice-chairman. To this committee the Minister will look for advice and information on all general questions affecting resettlement.

"In addition, Local Advisory Committees have been set up in connection with all the principal Employment Exchanges, consisting of representatives of the employers and trade unions in the principal local industries in equal numbers, to whom will be added for the purpose of demobilisation a certain number of representatives of local bodies particularly concerned with the welfare of discharged soldiers. It is hoped that a great deal of the work of finding employment for discharged men and of adjusting the difficulties which may arise in individual cases will be performed by these committees, which the Minister regards as a vital part of the machinery for the resettlement of industry.

"In addition to the general questions which will be dealt with by the Central Committee and the local or individual questions which will be dealt with by the Local Advisory Committees, there are a number of problems which can only be satisfactorily solved on a basis of industry. The Minister is accordingly very anxious that Joint Standing Industrial Councils shall be set up for the organised industries as soon as possible on the lines recommended by the Whitley Report, to which he would be prepared to refer immediately a number of problems which require careful consideration by workmen and employers sitting together. The functions of these councils in regard to resettlement would be co-ordinated by the Central Committee.

"By these means the Minister hopes to secure that arrangements shall be made for coping with the problems of resettlement over the whole field of industry, which shall be in harmony with national and local requirements, and also with the peculiar needs created by the conditions obtaining in each of the principal industries. The Government feel that the problem can only be successfully dealt with in close co-operation with employers' organisations and trade unions throughout the country, and the plan which has been drawn up and has been generally approved by the War Cabinet has been devised with that end in view."

An interesting announcement is made in *The Times* to the effect that the German General Commissioner of Trade Unions has communicated to all the German legislative bodies a "minimum" programme of reforms. The programme deals with economic and social questions under 18 headings, and demands the partial abolition of protection, the establishment of Government monopolies, Government control of syndicates, an Imperial Ministry of Labour, establishment of an eight-hour day, better protection of the interests of women and children, better representation of labour in industrial questions, and a clause in the treaties of peace concerning the adoption by foreign countries of politico-racial institutions which exist in Germany. There are also a number of proposals concerning housing, public health and education.

Manufacturers are faced with what many of them regard as a serious risk in providing themselves with materials for the resumption of peace-time production on a full scale. It is feared that materials bought at the greatly inflated prices which most things have attained, will, with the coming of peace, fall in price, either immediately or gradually, thereby involving the holders in loss.

It has been pointed out to the Minister of Reconstruction that fear of this contingency—whether a likely thing to happen or not—is tending to cause a

reluctance on the part of manufacturers and traders to acquire more materials (in readiness for the coming of peace) than will barely tide them over the contracts to which they are committed, and that they are leaving till a later date further purchases for the making of articles for stock. Dr. Addison, recognising that this holding-back is calculated to retard the attainment, after peace is declared, of maximum national productiveness, has appointed a committee of the Ministry of Reconstruction to go closely into the matter and see whether some way out of the difficulty cannot be devised. It is named the Committee on Financial Risks Attaching to the Holding of Trading Stocks. The duty of the new committee will be :—

"To inquire and to report as to any measures which could be adopted with a view to securing that manufacturers should be financially in a position to hold stocks after the war, and that reasonable safeguards are established to prevent serious financial losses as a result of possible depression following on a period of great inflation in respect of stocks of materials required for industry."

As the subject of inquiry closely concerns other Government departments and other Reconstruction Committees, representatives of these departments and committees have been incorporated in the new committee.

Any body or association of important trade interests, which wishes to have an opportunity of stating a case or presenting its views on the questions being studied by the committee, is requested to communicate with the Secretary, Mr. R. C. Smallwood, Ministry of Reconstruction, 2, Queen Anne's Gate Buildings, S.W.

Speaking in Parliament last Monday, Mr. Kellaway, Parliamentary Secretary to the Ministry of Munitions, said that the effect on industrial conditions in this country of the 12½ per cent. bonus had been thoroughly sound. He claimed that the bonus was one of the causes of the most satisfactory state of affairs which ruled since last November. The movement of workers as the result of the abolition of the leaving certificate had been comparatively slight; it had not been sufficient to interfere with the output of essential munitions of war, and he claimed that one of the reasons for that was the fact that the Government had decided on the 12½ per cent. bonus. In regard to the institution of a bonus and to its application, different views had been held by different members of the Administration. He, personally, had never had any doubt that the decision of the Government not to make the payment dependent on the introduction of payment by result was a right decision. Rightly, or wrongly, he added, that system was intensely disliked by certain sections of workmen, and he thought it would have been a profound mistake to enforce its acceptance. But the Government's policy had been, wherever possible, to encourage and to use whatever influence they had to secure the introduction and extension of the system of payment by results. He was glad to say that they had secured a considerable extension of the system. He hoped the men who were working it might make their influence felt by their fellows who were prejudiced against it, that the prejudice would be entirely removed and that they would succeed in getting the system made the general practice among our munitions industries.

The cost of the 12½ per cent. bonus, so far as it was applied to the classes for which the Ministry of Munitions was responsible, was, he claimed, 14,000,000*l.* The 14,000,000*l.* represented the estimate of the expense of the bonus to time-workers. In addition, there were the piece-workers, the arrangements relating to whom were in the hands of the Ministry of Labour.

As to the effect on production, Mr. Kellaway further stated, it was always difficult to attribute a particular effect to a particular cause, but the last half-year's output, with the 12½ per cent. bonus operating part of the time, showed the following increases of production as compared with the previous six months: Guns, 48 per cent.; machine guns, 20 per cent.; aeroplane engines, 68 per cent.; shipbuilding material, 25 per cent.

The statement made by Mr. Kellaway, reported above, referring to the difficulty of attributing a particular effect to a particular cause is a wise statement on his part. We believe most people will demur to the idea that the 12½ per cent. bonus has tended to increase production, although it may have conduced, as most concessions do, to less unrest. The increased production is probably due in a greater measure to the improved organisation of industries, for which employers do not get a full credit.

Some attention has been attracted during the last few days by news from Washington, to the effect that a strike of 2,000 ship carpenters had broken out, this being the only strike in the country affecting war preparation among 10,000,000 men employed directly or indirectly upon war work. President Wilson, in a telegram, urged the carpenters to return to work pending adjustment of their complaints by the regularly constituted Government agencies, adding: "Will you co-operate or obstruct?" The leaders thereupon consented to the men returning to work.

The Executive Council of the American Federation of Labour, at the close of a seven days' session, issued a declaration, of which the following is a brief abstract:

"We are face to face with a world crisis. We are in a world struggle which will determine for the immediate future whether the principles of democratic freedom or the principles of force shall dominate. The decision will determine not only the destiny of nations, but of every community and individual. No life will be untouched. Either democracy or autocracy will prevail. It cannot be a compromise or neutrality among nations or individuals. We must be counted for one cause or the other. There is but one choice for labour. Labour's hope lies in the opportunity for freedom. The workers of America will not permit themselves to be deceived, or deceive themselves into thinking that the fate of the war will not vitally change their own lives. A German victory means a pan-German Empire dominating Europe and exercising a world-balance of power which Germany will seek forcibly to extend to a world-control. . . . President Wilson's statement of war aims has been unreservedly endorsed by British organised labour, and is in absolute harmony with the fundamentals endorsed by the Buffalo Convention of the American Federation of Labour. We are at war for those ideals. . . . The gigantic struggle ahead will test to the uttermost the endurance, ability and spirit of our people. That struggle will be fought in mines, farms, shops, mills and shipyards as well as on the battlefield. Soldiers and sailors are helpless if producers fail to do their part. Every link in the chain of mobilisation of the fighting force and the necessary supplies is indispensable to winning the war against militarism and the principles of non-freedom. . . . The workers must soberly face the grave importance of their daily work and decide industrial matters with a conscience mindful of the world-relation of each act. The production problem is indispensable in preventing the unnecessary slaughter of our fellow men and is up squarely to all workers and employers. . . . The workers are loyal and want to do their share for the Republic in winning the war. This is labour's war and must be won by labour, and every stage of the fighting to final victory must be made to count for humanity, which result alone will justify the awful sacrifice. We present these matters to the workers of free America, confidently relying on the splendid spirit and understanding which have made possible present progress, enabling us to fight the good fight and to establish the principles of freedom throughout the whole world. . . ."

COPPER SULPHATE.—The Minister of Munitions has issued an Order dated the 14th inst., governing the prices of copper sulphate. All applications in reference to the said Order should be addressed to the Director of Acid Supplies, Ministry of Munitions, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, and marked "Copper Sulphate."

THE METRIC SYSTEM.—The following extract is taken from *The New York Tribune*, dated January 22 last: "Adoption of the metric system of measurements for artillery and machine guns and maps for the American overseas forces was announced to-day by the War Department. The change was agreed upon at the suggestion of the French Government to avoid confusion in France, where the metric system is used exclusively."

MELTING-POINT OF COAL ASH.—In some iron-ore briquetting works of the north country the briquettes were taken in wagons through the furnace, and trouble resulted with certain kinds of coal, as the melting ashes clogged and jammed the wagons. Dr. J. T. Dunn, therefore, studied the melting-points of the ashes from 16 coals from Northumberland, Durham and the West of Scotland. Analysing the ashes he confirmed (Journal, Society of Chemical Industry, January 15, 1918) on the whole the conclusion of Richters, who found, fifty years ago, that the melting-points of the ashes were reduced as the proportion of basic oxides increased. The basic oxides would be those of aluminium (Dr. Dunn found 25 per cent. to 45 per cent. of this oxide), iron (1 per cent. to 25 per cent.), lime (up to 6 per cent.), magnesia (up to 3 per cent.), alkalis (up to 7 per cent.), titanium (up to 2.5 per cent.), manganese (mostly traces). With decreasing basic oxide the melting-points of the ashes rose from 1,150 deg. to 1,500 deg. C. Of two other coals tested, the one from Natal proved the worst, the ashes melting already at 1,020 deg. C., and one from Spitzbergen the best; this latter ash was practically a china clay. The Natal coal contained 22.8 per cent. of lime, 6 per cent. being quick lime, 9 per cent. of sulphuric anhydride and 1.6 per cent. of phosphoric acid, and the low fusibility was quite natural in that case. Much depends, of course, on the particular nature of the oxides and not only on their total amount; that was quite understood. Some Continental railways are said to stipulate a minimum melting-point of 1,400 deg. C. for their coal ashes. The high alkali percentages of some of the ashes deserves attention.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 20th inst., at the society's rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., president, in the chair.

Mr. F. A. Bellamy, M.A., read a paper on "*The Barometer Record at the Radcliffe Observatory, Oxford, with Special Reference to Professor Turner's Suggested Discontinuities.*" Professor Turner has, in several papers to the Royal Meteorological Society, claimed that meteorological history is divisible into "chapters" of an average length of six and a-half years each, and has assigned the dates at which a new "chapter" opens (when there are abrupt discontinuities in meteorological phenomena) with considerable precision for the last two centuries. The evidence has hitherto been based upon the monthly mean values of rainfall and temperature, and he has shown that these monthly means differ systematically in the "even" chapters as compared with the "odd." To examine whether such systematic differences extended to periods shorter than one month, Mr. F. A. Bellamy has analysed a series of sixty-two years' daily barometer records made at the Radcliffe Observatory, Oxford, many of them made by himself while there in 1891–92. He collected all those records into daily groups and found the means of the differences between "even and odd chapters" for corresponding days; these were in many cases quite large, but apparently no larger than similar arbitrary differences for any arbitrary selection of years that was made. Only one such arbitrary selection was used for comparison, but it is probably sufficient to substantiate that statement. Proceeding now to combine two consecutive days together, then three such days, and so on, in groups of six up to 180 days, Mr. Bellamy found that the differences between corresponding groups of even minus odd still remained "accidental" in character (*i.e.*, they were no larger than the arbitrarily selected set) until the number of days combined reached about thirty days; but from this point the even-odd set began to show an excess which gradually increased until the differences became twice as great. The inference is that for periods from one to six months there is a decided difference in the even and odd chapters for atmospheric pressure, even for one station, as there has been shown for rainfall and temperature from many stations in the world; and that the matter of discontinuities is supported.

A paper by Dr. C. Chree, F.R.S., was also read, entitled "*The Diurnal Variation of Barometric Pressure at Seven British Observatories*, 1871–1882." The diurnal variation of atmospheric pressure, as of any other element, can be analysed in Fournier terms or "waves" of periods 24 hours, 12 hours, 8 hours. In the case of the mean diurnal variation from all months of the year combined, the 12-hour wave appears of a very dominant character, the amplitude being nearly the same for all stations in the same latitude, and the phase referred to local mean time being everywhere nearly the same. The 24-hour wave, on the other hand, is very variable, and the 8-hour wave small compared with the 12-hour wave. Taking the seven stations—Valencia, Armagh, Glasgow, Aberdeen, Stonyhurst, Falmouth and Kew—it is pointed out that the comparative unimportance of the 8-hour wave in the mean diurnal inequality for the year arises in great measure from the large difference that presents itself between the phase angles in two different seasons of the year. In individual months the 8-hour wave, though considerably smaller than the 12-hour wave, is far from negligible, and the phenomena presented by the 8-hour wave at the seven British stations exhibit almost as close a similarity as those presented by the 12-hour wave. The paper also considers a theory as to the nature of the 12-hour wave recently advanced by Dr. G. C. Simpson. It discusses the theory from the point of view of the variation in the phenomena throughout the year, and shows how some of Dr. Simpson's mathematical expressions can be put in a simpler form of sufficient accuracy in the case of stations in low or middle latitudes.

UNITED STATES SHIPPING.—In the first annual report of the United States Shipping Board, the fact stands out conspicuously, says *The Marine Journal*, New York, that as soon as Chairman Hurley took charge and expert hands began to guide the work of commandeering and construction, there came a mighty impetus in the erection of a new American merchant marine. The following table is given in our contemporary :—

Type of Vessel under Contract.	August 1, 1917.		October 31, 1917.	
	No. of Vessels.	Tonnage.	No. of Vessels.	Tonnage.
Wood	235	840,000	375	1,330,900
Steel	70	587,000	305	2,285,000
Composite	58	207,000	58	207,000
Total	363	1,634,900	738	3,820,900
Requisitioned August 3, 1917:				
Steel	—	—	413	2,937,808
Total	363	1,634,900	1,151	6,758,708

In addition, the report states that there are prospective contracts pending for the construction of 199 additional steel ships, of a total deadweight tonnage of 1,100,000 tons.

PLANT FOR THE MANUFACTURE OF RETORTS FOR THE DISTILLATION OF ZINC.

CONSTRUCTED BY MESSRS. WILLIAM JOHNSON AND SONS (LEEDS), LIMITED, ENGINEERS, LEEDS.

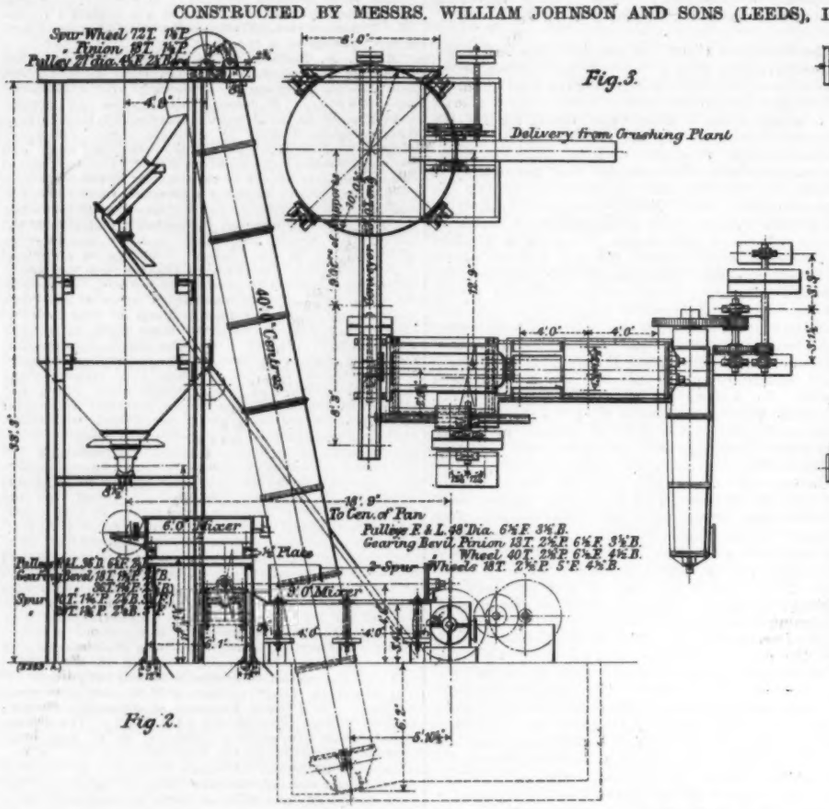
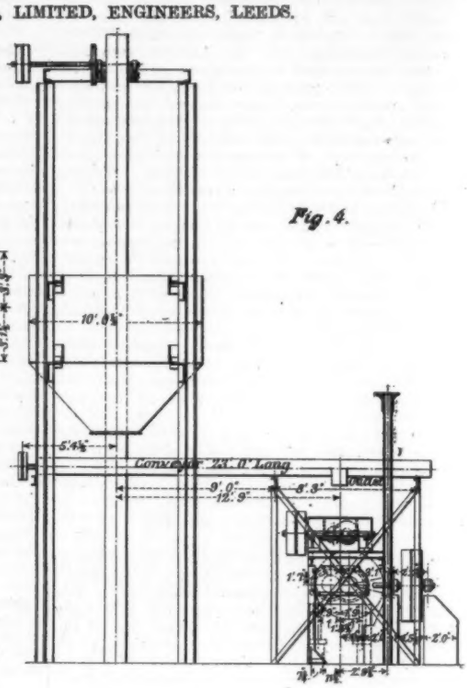
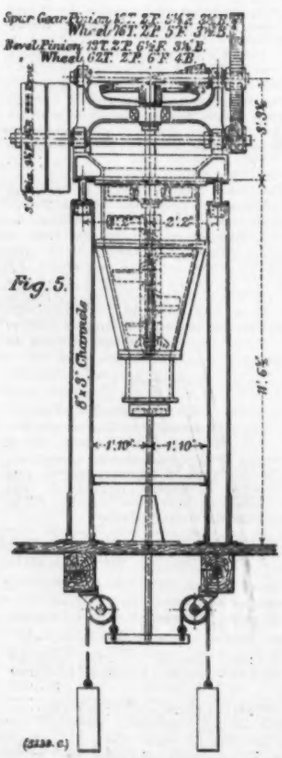
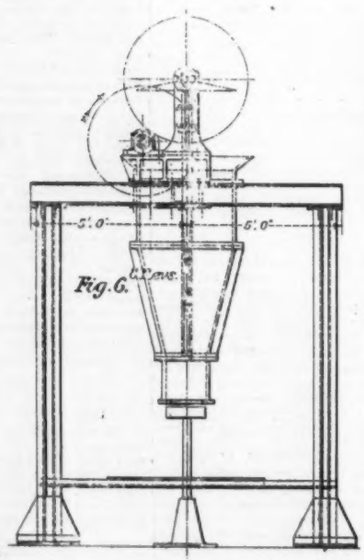
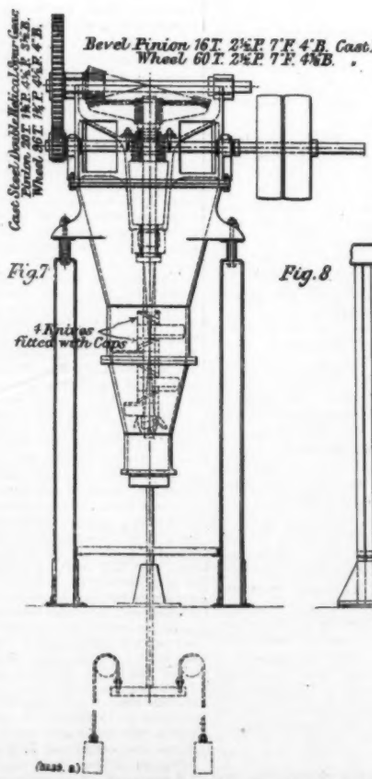


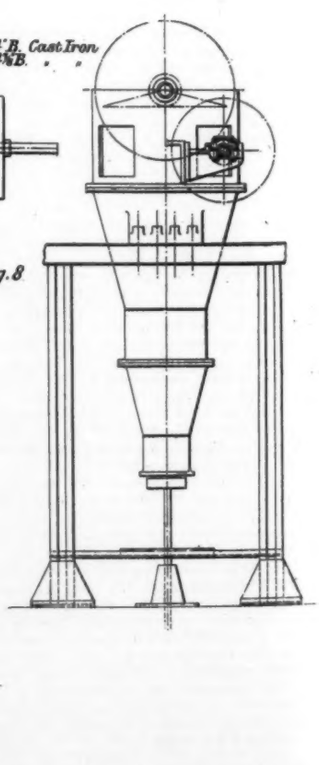
Fig. 3.
Delivery from Crushing Plant
Conveyor
To Cen. of Pan
Pulley F. & L. 48" Dia. 6¾ F. 3½ B.
Gearing Bevel Pinion 13 T. 2½ P. 6¾ F. 3½ B.
Wheel 40 T. 2½ P. 6¾ F. 4½ B.
2 Spur Wheels 18 T. 2½ P. 5" F. 4½ B.











THE BRITISH SPELTER INDUSTRY.

(*Concluded from page* 169.)

THE manufacture of the retorts requires great care and has to be effected in the works, since the finished retorts cannot be transported. The ordinary raw material for the retorts over here was a mixture of good clay, Belgian and English, both well-matured raw clay and the burnt material; since the outbreak of the war retorts have successfully been made by mixing various qualities of English clay. High-grade silica clays are used in Silesia. The plant for preparing the clay consists of a jaw crusher discharging into a disintegrator; from the disintegrator the ground clay is elevated (see Fig. 2 above) to a screen $\frac{1}{16}$ mesh suspended over a hopper capable of holding 10 tons of ground clay. From this hopper the material is discharged into a conveyor (Fig. 3), and is then fed into a 6 ft. differential mixer, which eventually discharges into a 9 ft. differential mixer, and then passes on to 12 ft. pugmill (Fig. 2, 3 and 4).

PLANT FOR THE MANUFACTURE OF RETORTS FOR THE DISTILLATION OF ZINC.

CONSTRUCTED BY MESSRS. WILLIAM JOHNSON AND SONS (LEEDS), LIMITED, ENGINEERS, LEEDS.

Fig. 9

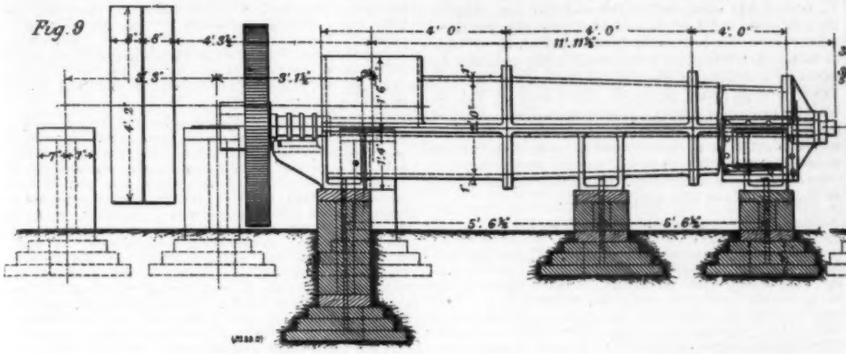


Fig. 10.

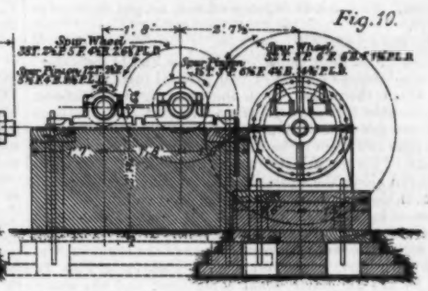


Fig. 11.

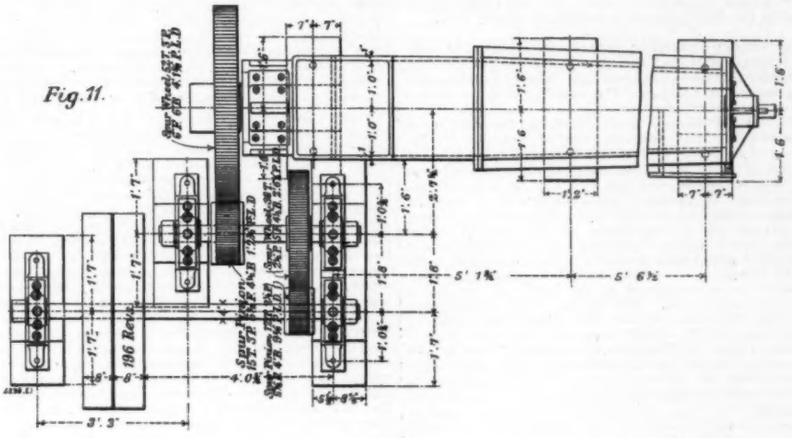


Fig. 12.

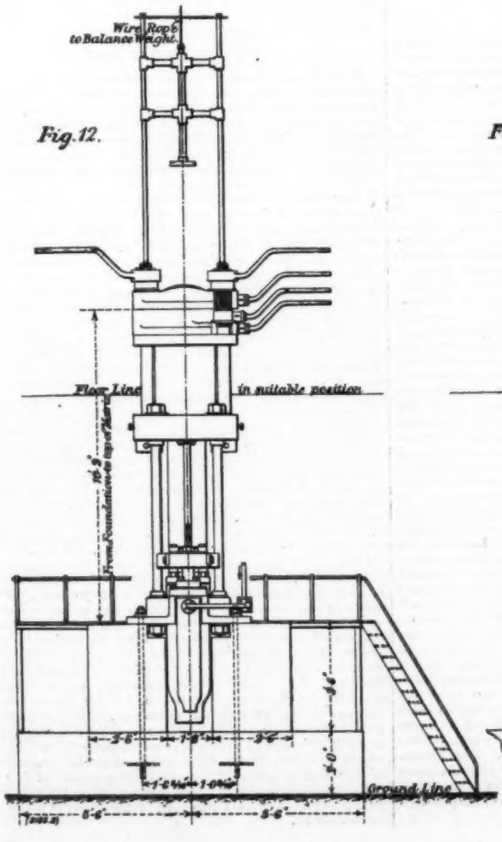
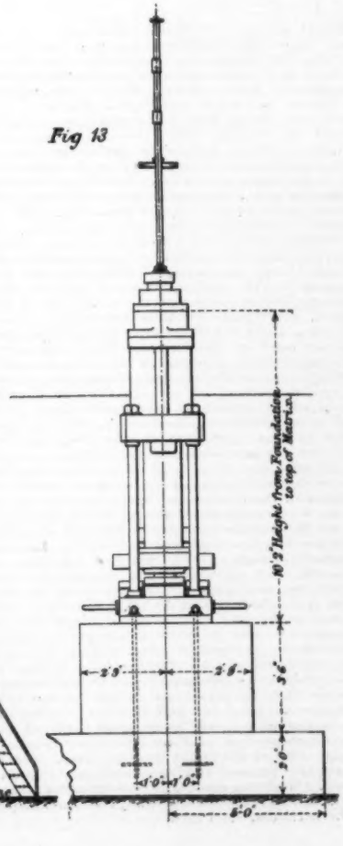


Fig 13



placed at right angles to the mixer, where it is rendered sufficiently plastic for pressing. The pug mill is illustrated separately in Figs. 9 to 11, annexed.

Double mixing is necessary, as it is very important that the grog and raw clay should be intimately mixed before being pugged so as to ensure a sound retort. The clay after being pugged is placed in a maturing room where it remains for several days. It is then elevated to the vertical pug and ballot maker (Figs. 5 to 8 on page 200). Figs. 5 and 6 show a Mahler's design and Figs. 7 and 8 an improved type in which the clay can be fed through an open top, and the knives can be changed without dismantling the machine. The ballots of clay are cut to suitable lengths and transferred to the press.

The retorts are made of various shapes, round and oval, with flat bottoms like gas retorts, &c.; Figs. 14 and 15, page 204, show a favourite shape. On the older methods the mould was filled with clay, and the clay then hollowed out with a drill. The modern practice prefers hydraulic presses; the press illustrated in Figs. 12 and 13, annexed, is of the type which Mahler introduced in 1883. In this type one central hydraulic cylinder is surrounded by two (four in the Dor-Delattre press) smaller cylinders, the rams of which carry pistons which enter the mould chamber above the cylinders. This chamber is closed by a cover, under which lies the annular die which gives the retort its external shape. After loosening the bolts with the aid of the levers shown in Fig. 12, the cover and the just-mentioned die can be turned about the left-hand rod, so that the lump of clay can be dropped into the chamber. The cover is closed and the hydraulic pressure turned on. The central ram, being larger than the others, alone rises at first and forces its piston up through the clay. The piston bears on its top a die which determines the internal section of the retort, the back of which is formed between the cover and the two dies. The pressure is now cut off momentarily, the cover turned sideways once more, and the pressure is put on again. The two small rams then move; they had so far been kept down, together with the piston they actuate which surrounds the main piston like a cylinder. As this ring piston rises it forces the clay through the annular port between the inner and the outer die, so that the retort tube projects from the chamber to the desired height. When this height is reached the length of soft clay retort is cut off with a brass wire. To guide and protect this soft mass a hood is suspended above it by means of a balance-weight.

After the retort is pressed it is transferred into drying and maturing rooms—each room being sufficiently large to hold 500 retorts or thereabouts. The drying or maturing of the retorts takes about three months. The trade practice is to allow these retorts to remain in the maturing room for a greater period than this if in any way possible. The well matured retorts when required for use are annealed in kilns, prior to their being charged to the furnace, to a temperature approximately equal to that of the combustion chamber in which they are to be placed. The retort dimensions vary much; lengths of 150 cm., heights of 20 or 35 cm., wall thickness of 20 to 30 mm., and weights of 75 kg. may be averages.

The condensers for the retorts are known as adapters or prolongs, nozzles or collectors. The adapters (see Fig. 14, on page 204) are doubly-conical or belly-shaped clay tubes, also made by machinery now, and luted into the retort when *in situ*; the zinc vapour is liquified in the adapter. In front of the adapter, again, and held there by wires, is the collector or nozzle; it is generally made of sheet iron and is

provided with partitions so as to catch the pulverulent zinc fumes or dust. The Steger nozzle, which resembles an upright Z, has given satisfaction in Silesia; from the upper nozzle end a pipe extends into a flue in which the CO is burnt. The molten zinc is scraped out of the adapters into a casting ladle and run into a mould. The slab or ingot produced weighs on average 44 lb.

In the furnaces several tiers of retorts rest slightly inclined with their backs on ledges, as Fig. 14 indicates; double furnaces consist of two parallel rows of retorts, of which there may be a thousand in one furnace. The double furnaces shown in Figs. 14 and 15, page 204, are gas-fired with producer-gas on the regenerator principle and seem to be designed for a uniform distribution of the temperature about the retorts. Two main flues run along the furnace, not directly underneath the bottom tier, however, which was overheated in some types of furnace.

In older types the retorts of the different tiers were not all of the same dimensions, nor at the same angles. The 120 retorts of a double furnace shown in Figs. 14 and 15 are all under equal conditions, and the waste heat chambers of the furnaces are interconnected.

With many tiers of retorts in distillation furnaces the charging of the mixed charges and discharging of the residues becomes very awkward, as does likewise renewing of defective retorts. The three-tier furnace shown in Figs. 14 and 15, has been so designed that the higher and lower tier can be manipulated with ease by a workman of average height. When the three-tier furnace is superseded by furnaces of 4, 5 or 6 tiers, it will be necessary to provide movable platforms to reach the higher tiers. That would tend to additional plant in the form of elevators and charge-storage hoppers for each furnace and structural work to support them, so as to avoid extra labour.

As regard charging and discharging and the general lay-out of the furnace department of zinc works, smelting costs would probably be considerably reduced by the adoption of vertical retorts. Research should be invited to prove whether or not the distillation could then be made continuous. With the horizontal retort furnace the campaign takes about 24 hours. Half-an-hour or an hour are occupied every morning by the renewal of retorts left defective from the previous campaign. The discharging of the residue of the previous distillation occupies two hours, the introduction of the new charge including the fixing of the adapters and luting, &c., claims another two or three hours, so that unfortunately only 18 hours remain for the distillation. In the vertical retort these duties might greatly be accelerated, extending the period of distillation to about 22 hours. It may be argued that the zinc fume would not penetrate through a dense charge in a vertical retort, and that the slag formed in the hottest zone would tend to retain the zinc. These difficulties do not appear unsurmountable. In the case of fine ore, such as Broken Hill concentrates, the difficulties might be overcome in suitably designed furnaces by intimately mixing the roasted product with the reducing material and briquetting it to "eggette" shape or some similar convenient size.

During the distillation blue flames of CO first make their appearance at the adapters; when the flame brightens up with zinc vapours the collectors are attached. The dust settling in them during the first hour or two is collected separately, because it is richest in cadmium, which is more volatile and more easily reducible than zinc; the cadmium is subsequently refined by fractionated distillation. The proportion of reduced zinc which is condensed as dust is rarely less than 4 per cent. and may rise to 10 per cent.

From this résumé it will be understood that zinc sulphide smelting cannot be carried out profitably on a small scale—the sulphuric acid lead chambers do not answer either unless worked on a fairly big scale—and that the 8 acres of ground which Messrs. Johnson and Son provide for their plant will be needed.

There have been notable improvements of late in the metallurgy of zinc, especially in the furnaces. But there remains much to be desired, particularly in hygienic respects, and processes other than the ordinary zinc distillation continue to engage serious attention. Zinc sulphide has been decomposed, in connection with iron or copper works, by molten metals, when zinc vapours escape. As these processes did not answer, furnaces were constructed for the production of zinc oxide, with no greater success. J. Swinburne and Ashcroft, twenty years ago, treated Broken Hill sulphides with chlorine at 600 deg. C., liberating the sulphur and gaining zinc chloride for electrolysis. Hoepfner had before that electrolysed aqueous solutions of zinc chloride under various conditions; for some years, at any rate, Messrs. Brunner, Mond and Co. had a process in operation at Winnington in which calcium chloride, the waste product of the ammonia-soda process, was utilised as solvent for zinc oxide. Zinc sulphate, obtained by leaching roasted sulphide with sulphuric acid, has been electrolysed with some success in various works. Lixiviation of the roasted ores with sulphurous acid and decomposition of the resulting zinc bisulphite by heat into SO_2 and zinc oxide has also been attempted; electrolysis of sulphite solutions, and also of alkaline solutions has not been successful. R. Lorenz has tried electrolysis of fused zinc chloride; this chloride must be made and kept anhydrous, and when the water has really been expelled, the "fogs" of metal dissolving in the fused salt cause trouble. Hot aqueous solutions of metallic chlorides, on the other hand, corrode metal pipes, &c., very badly. Yet electrolytic processes should not be disregarded. They are perhaps more promising than the direct smelting of sulphidic ores in electric furnaces, both of the arc and resistance types, though partial success was obtained by Côte and Pierron and others. Some day the metallurgy of zinc in the wet way may triumph.

Additional Maximum Prices for Type Metal.—With reference to the Order of September 1, 1917, made by the Minister of Munitions, controlling lead, and fixing certain maximum prices, the Minister of Munitions has, as from the 19th inst., included in the said Order type metal; spacing material; electro-plates and blocks; stereo plates, metal and blocks; linotype and monotype metal, and given prices for each. The new Order may be cited as the Lead Control Amendment Order, 1918.

Reinforced-Concrete Buildings.—Unusually difficult conditions of load distribution have to be met in a reinforced-concrete warehouse and factory building now being erected in Chicago. The building is of five storeys with a basement, and it covers an area of 45 ft. by 75 ft. In the factory large punch presses will be in operation, but the heaviest load will be due to the storing of steel plates and bars. For this latter purpose a width of 12 ft. along the one side of the second floor has been set aside, and the load will be 2,000 lb. per square foot. Support is provided by 12-in. concrete partition walls, which are built on foundation girders and extend up to the bottom of the heavily loaded portion of the second-storey slab. In the basement and on the first storey these walls are utilised to support racks for the storage of steel rods, the racks consisting of rows of heavy pipes embedded in the walls and projecting 18 in. on either side. This flooring for heaviest loads makes up 33 per cent. of the whole area. The remaining 67 per cent. of the second storey and the entire area of the first storey are designed for a load of 1,000 lb. per square foot, while the allowed load for the upper three floors is 600 lb. per square foot. The foundation, a concrete slab laid directly upon the clay, is surmounted by girders running in both directions, the interior columns being located at the intersections of these foundation girders.

The Hardening of Steel.—We gave in one of our former issues (Engineering, vol. civ, page 71), under the title "The Hardening of Gauges," a short description of the Wild-Barfield automatic steel-hardening furnace, as applied to direct current. We are now informed by the makers, Automatic and Electric Furnaces, Limited, 6, Old Queen-street, S.W. 1, that they have devised a new method of working with alternating current. The alternating-current furnace is similar in construction to the continuous-current furnace; it differs from it only in the means adopted for obtaining an indication as to when the steel in the furnace arrives at the temperature of decalescence and is ready for quenching. The furnace consists of an inner crucible containing molten salt and heated by a wire helix wound on its outer periphery. This crucible is surrounded by lagging material, and is contained in an outer case, on which is wound a coil of copper wire. The heating helix and the outer coil thus constitute the primary and the secondary of a transformer. The furnace windings are coupled up in series with the primary and secondary windings of an auxiliary induction coil or transformer. The coupling is such that the voltage induced in the furnace secondary winding is opposed by that in the secondary winding of the auxiliary induction coil. In the secondary circuit is inserted an indicating instrument, which takes the form of a vibration galvanometer. Before any steel article is introduced into the furnace, the voltages induced in the two secondary coils balance exactly, and the galvanometer receives no current, and its "spot" remains perfectly steady. As soon as a steel article is placed in the furnace the steel is magnetised by the heating winding, the total amount of magnetism passing through the secondary winding is increased, the secondary voltage is also increased, balance between this and the secondary voltage of the auxiliary induction coil is destroyed, and an alternating current is circulated through the indicating instrument, which is indicated by the spot vibrating and its image becoming confused. As soon as the steel arrives at the temperature of decalescence it also becomes non-magnetic, thereupon conditions are restored to what they were before the steel was introduced into the furnace and the "spot" immediately stops vibrating. It is thus known with certainly that the steel has arrived at the true decalescence temperature, and if it is withdrawn and quenched at once it will be properly hardened without being overheated, a condition absolutely necessary for cutting tools of the finest possible grain, and consequently the keenest and most enduring edge is thus secured. With this process no skill whatever is required, and the results obtained will always be the best possible for the particular steel used.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Sheffield Gas Profits.—The annual report of the Sheffield Gas Company shows, notwithstanding an increase in gas sold of no less than 457,451,000 cub. ft., profits have dropped from 110,048*l.* in 1916 to 51,403*l.* last year, being less than half of either of the two preceding years. This the company put down to the large advance in workmen's wages, the increased cost of coal, and the enormous extra cost of all materials used. They propose to advance the price of gas by 7*d.* per 1,000 cub. ft., bringing the rates up to 2*s.* 4*d.*, 2*s.* 1*d.* and 1*s.* 11*d.*, according to consumption.

Iron and Steel. — Every effort is being made to keep up the supply of hematites. Two new furnaces have recently been started on the North-West Coast, but to improve the supplies to the open-hearth furnaces the Ministry of Munitions has put Bessemer plants on short rations, and in some instances has ordered that they be closed. Bessemer acid steel is consequently being produced in limited tonnage. The deficiencies in transport and scarcity of wagons is also having an adverse effect on the situation. Deliveries of Welsh basic billets to Sheffield has again been resumed after a considerable stoppage following the South Wales strike. Prices, however, are again advanced. Locally shell makers are well in advance of requirements. Acid and crucible steel-makers are turning out a huge tonnage, but still find it difficult to keep pace with the demand, especially for qualities suitable for aeroplane work. The Government have placed during the week substantial contracts for agricultural implements of various kinds, including weeding hoes, garden shears and industrial knives. A moderate tonnage of steel has been despatched to the ports for shipment to Canada, the United States, Italy and India.

South Yorkshire Coal Trade.—A full demand continues for all classes of fuel, with production sufficient to ensure fairly satisfactory deliveries. The chief difficulty continues to be lack of transport facilities, and reports are to hand of short time being worked at some pits owing to a scarcity of wagons. The control of distribution leaves practically no coal on the open market. The whole of the huge output, if we except comparatively small tonnage allowed to go on export account, is readily absorbed by munition and other works on contract, in furnaces, and by the railways. Steam nuts are still scarce, and slacks in heavy demand. Blast-furnace coke is very active, the whole output being readily taken up at maximum rates. Gas coal is a little easier. In house qualities merchants find a difficulty in securing adequate supplies, the demand still being heavy on inland account for the metropolitan market. Prices current at the pit are as follow:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

The Patents and Designs Bill.—A private and informal meeting of members of the Institution of Electrical Engineers will, by kind permission, be held in the Lecture Theatre of the Institution of Civil Engineers, Great George-street, Westminster, S.W., on Thursday, February 28, 1918, at 2.30 p.m., for the purpose of discussing the provisions of the above Bill, &c.

The Optical Society.—The annual meeting of the Optical Society was held at the Imperial College of Science and Technology, on February 14, the president, Professor F. J. Cheshire, C.B.E., in the chair. The council's report was presented, and the election of officers and council for the year 1918–19 was announced as follows:— President, Professor Cheshire; hon. treasurer, Mr. H. F. Purser; hon. librarian, Mr. J. H. Sutcliffe; hon. secretaries, Mr. Wm. Shackleton, A.R.C.Sc., and Mr. T. Smith, B.A.; members of council, Naval Instructor T. Y. Baker, R.N., Mr. P. F. Everitt, Mr. James W. French, B.Sc., Mr. E. B. Knobel, F.R.M.S., and Mr. Frank C. Watts. Various alterations to the rules were made by which honorary members are in future to be designated honorary fellows, and a new class of membership formed termed "Fellows." A paper on "Reflecting Prisms" was afterwards read by Naval Instructor T. Y. Baker, R.N., of the Admiralty Compass Observatory, in which he advocated the use of prisms in place of mirrors as being easier to mount and as requiring, in many cases, no silvering. A series of suitable designs for certain double-reflecting prisms, in which the light is made to deviate by a fixed amount, was shown for angles 0 deg., 15 deg., 30 deg. . . . 90 deg., the form in each case being that which gave maximum aperture to the prism. A special form of triple-reflecting prism with angles of 30 deg., 30 deg. and 120 deg., was described, which Mr. Baker considered would be much more suitable for the horizon glass of a sextant than the customary plane mirror, as it would enable the telescope to be placed close up to the prism without any danger of cutting off light between the two mirrors. To avoid this happening in an ordinary sextant the horizon glass has to be set at an angle of 75 deg. to the axis of the telescope, and the latter set well back so that the angular aperture is equivalent to 15 deg., whereas with the prism described the aperture would be about 50 deg., and angles could be measured up to 170 deg. in place of the maximum range of 150 deg. in an ordinary sextant. The discussion on the paper was adjourned to the next meeting of the society to be held on March 14.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Little, if any, change falls to be recorded in connection with the local steel-making industry. Every establishment is as actively employed as is possible, every available mill is running unceasingly, and practically the only way in which outputs could be further increased would be by employers being able to lay claim to the services of additional workers. Meantime there is very considerable pressure for delivery of the finished and semi-finished steel on Government account. Indeed, as things are at the moment no other class of work can be dealt with, with the exception of some being supplied to the Allies. So long as shell discard steel was available for general purposes the ordinary mercantile consumer was not so badly off, but even this grade of material is now being extensively used for war work, and none is available for any other purpose. The continued activity in the shipbuilding yards makes heavy demands upon the steel works, ship plates and sections being required in exceptionally large quantities.

Malleable Iron Trade.—In the malleable iron trade it is just one continuous tale of ceaseless activity to turn out the work as expeditiously as possible. While bars of all qualities and sizes are in great request, perhaps at the moment the heaviest pressure is for the lighter sections and the smaller sizes required for nuts and bolts. These are being supplied in very large quantities, and there is every expectation that this will continue for some time. The steel departments are almost as busy as the iron departments. Home rates for "Crown" bars remain at the level quoted last week, but the probability is that these will be advanced immediately. For export, 16*l.* to 16*l.* 5*s.* per ton, and even upwards, is readily paid.

Scotch Pig-Iron Trade.—The endeavour to keep the steel and iron works supplied with the material which is so urgently required for the purposes of the war has created and maintained in the pig-iron industry a flow of business hitherto unknown in the trade, a state of affairs, too, which will last as long as the war continues. It would scarcely be possible for more to be attempted. In some cases the supply is short, several well-known brands of foundry being practically unobtainable just now. Otherwise the demands are being satisfactorily met.

Clyde Shipowners and the War.—Presiding at the annual meeting of the Glasgow Shipowners' Association at the end of the week, Lord Inverclyde drew attention to the very active part the Clyde shipowners had taken in supporting the Admiralty and the Government in their prosecution of the war. Shipping, his lordship remarked, had been fraught with great difficulties, but shippers had gladly done all in their power to help with what had to be undertaken, and the results are certainly most satisfactory and most encouraging. His lordship intimated that a meeting with Sir Joseph Maclay, the Shipping Controller, had just been arranged, when it was hoped that some solution of the shipping problem might be arrived at.

ROUMANIAN PETROLEUM.—A German oil authority, lecturing recently at Bucharest, stated that the fuel value of Roumanian petroleum was very high, viz., 11,000 calories per kilogramme, as against 8,000 calories for the best Welsh steam coal. Germany hitherto has obtained oil from her ally Austria-Hungary, which country in 1913 produced well over 1,000,000 tons of crude. *The Motor* suggests that Germany evidently anticipates an enormous development of the Diesel engine. Thus it may be expected that Germany will get a grip of all the oil sources she can and be independent of coaling stations. An 8,000-ton ship, with Diesel engines, can make the trip to Japan and back on 700 tons of oil only.

THE LATE MR. JOHN KENNEDY.—We regret to record the death of Mr. John Kennedy, of 11, Fellows-road, Hampstead, who died after several months' illness, on the 14th inst., at the age of 78. Mr. John Kennedy was the second son of the late Captain Robert Kennedy, banker, of Oban, N.B., and was educated at Greenock Academy, after which he served his apprenticeship as engineer with Messrs. McNab, of Greenock. He then went to sea for seven years, the last five as chief engineer, after which he entered the firm of Messrs. R. MacAndrew and Co. as superintending engineer, with whom he was attached for forty years. He was a founder and chairman of both the Glengall Iron Works, Limited, and the British Arc Welding Company, Limited, and was a director for fifteen years of the Antwerp Water Works Company, Limited, which position he resigned some six months back.

THE NATIONAL EMPLOYERS' FEDERATION. — The National Employers' Federation was founded in 1913 as the Midland Employers' Federation, and it did good work for several years in settling disputes on an equitable basis. About 900 conferences have been held with trade unions, and in no single instance have the unions found it necessary to declare a strike. At first (1913) the federation comprised 75 members, with a wages assessment of 2,350,000*l.* It grew steadily until, in November, 1917, the members numbered 412 and the wages were 10,000,000*l.* In July, 1917, the name of the body was changed to the National Employers' Federation, and the head office was established at 38 and 39, Parliament-street. In the coming time there will be great need for employers to be enrolled in great organisations if they are to negotiate successfully with organised labour.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is no dearth of Cleveland pig-iron, and in fact some of the makers have rather considerable stocks, and as a consequence no difficulty is experienced in obtaining supplementary allocations for this month. Issue of such allotments, however, is no guarantee of delivery, but it is gratifying to learn that the truck situation is showing improvement, and with more wagons coming forward February distribution promises to be larger than was anticipated. Demand continues very keen, and business is much more brisk than has been usual for some time past at this period of the month. Further very substantial inquiries for forge iron on forward account are not leading to sales to any extent, producers still being disinclined to commit themselves ahead. Moreover, furnaces are now working much better than they have been, and consequently less of the lower qualities of iron are being turned out to come on the market. Foreign business is very quiet. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge, all stand at 75*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are all quoted 114*s.*, and No. 1 is 119*s.*

Hematite Iron.—The recent restriction in the production of East Coast hematite iron is very largely counterbalanced by the increasing use of basic iron manufactured from native ores, so that the smaller output of hematite iron is still sufficient to deal with essential home needs, but very little surplus indeed is now left to meet the demands of the Allies. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Foreign Ore.—New business in foreign ore is small, and is quite of the hand-to-mouth kind, but, under running contracts, supplies are reported coming steadily to hand in fairly satisfactory quantities.

Coke.—Coke keeps its value well. The continued large demand is met by very ample supply, and considerable business is passing. For home use, average blast-furnace quality is 33*s.* at the ovens, low phosphorus kind 35*s.* 6*d.* at the ovens, and foundry descriptions 38*s.* For shipment, gas-house product is 38*s.* to 40*s.* f.o.b., and foundry coke 42*s.* 6*d.* f.o.b. to the Allies, and 45*s.* f.o.b. to neutrals.

Manufactured Iron and Steel.—With the pressure for delivery of manufactured iron and steel to meet the huge demands of the Government, and of the shipyards unabated, producers are kept very fully employed, and are not at all disposed to entertain ordinary commercial inquiries. Prices, all round, are very strong, but the only actual alteration announced is an advance of half a crown per ton in iron bars. To home customers common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel billets, 11*l.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export prices may be given as 40*s.* above home quotations.

CANVAS TUBING FOR MINE VENTILATION.—At the North Butte Company's mines in Montana considerable trouble was experienced from the natural heat of the rock when the mine was to be deepened from the 3,100-ft. level to 3,700 ft. early in 1916. The men dropped out because a good supply of cool air could not be maintained through the heavy galvanised-iron tubing which was always getting out of order. Canvas tubing was therefore adopted. As first supplied, sections of the canvas were joined over a hoop, 6 in. wide, of iron, and held together by wiring. This did not answer. Then each section was delivered with a ring at each end; each ring has a slip joint, and one of the two rings is contracted to fit them into one another; when placed together they form a circular channel, and the canvas being sewn on at each end acts as a gasket to prevent leakage. This jointing proved quite strong. At the first installation 500 ft. of this tubing were taken down in one cage, together with three men, while the galvanised tubings would have made up eight skipfuls, and the canvas tubing was strung up, ready for ventilation, in 2 hours. In pushing the shaft further down through the granite, which had a temperature of 100 deg. and even 105 deg. F., the end section, exposed to rough wear, was always removed, and a new piece was fixed in above it. In some cross-cuttings the temperature was cool, 65 deg. F., but blasting went on constantly, and it was very difficult to clear the air at the breast of the smoke. A suspension wire was stretched with the aid of the overhead fixings of the trolley line; the rings in the canvas tubings had been provided with clips for suspension, and tension bands were placed over the joints. This seemed satisfactory, but on the morning after hanging the tubings, sacks of water were found in the tubing. Grommets were then put in the end of each section and plugged with corks; the fires were shut down for a few minutes each morning to allow the ditchman to run the water to the end of a section, pull out the cork, tie up a short section, and move on to the next section; having drained all the sections he would start back, untying the canvas and replacing the corks, and all would be well for another 24 hours. A special blasting-piece had had to be made and fastened to ears sown to the hem of the tubing. In raises and stopes the tubing was roughly encased to protect it against fall of rock.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The chief point of interest at the markets at the present moment is the scheme which has been prepared by the Coal and Coke Supplies Committee for the allocation of orders, and which is to be submitted to the Controller of Coal Mines for his approval. The main purpose of the scheme is to secure, if possible, such a distribution of orders as may equalise working conditions more favourably than that which obtains under a competitive system. Views are rather sharply divided as to the advantages which may be derived by the coalfield as a whole. While some collieries regard the scheme hopefully, others consider it as a measure which is almost certain to reduce their outputs. The details have not yet been disclosed, but it is anticipated that the trade will be informed of the Controller's decisions immediately they have been arrived at. The supply of wagons for the inland markets is now more satisfactory, but there is nevertheless room for considerable improvement, and complaints are still common of the employment on return journeys of colliery-owned wagons. There has been experienced a shortage of pitwood, but this week there is a slightly better delivery of home-grown timber. Iron ore stocks are running short, but not to the extent of affecting work at the collieries, and further supplies are now expected.

Newport.—There is no change to report in the position of the Newport coal market. The collieries in the Monmouthshire area are fairly well employed this week, but they are dependent entirely upon day to day conditions, and in hardly any case is there an assurance of continued employment for more than 24 hours ahead. The inland demand continues strong, but collieries could do with a better supply of wagons.

The Miners' War Wage.—Several points of dispute have arisen in connection with the payment of the war wage of 1*s.* 6*d.* per day to colliery workers. The Coal Controller has now decided two of these, and both in favour of the workmen. One is that men employed on afternoon and night shifts are to be paid six turns for working five, and another is that a man is entitled to the day's wage provided he starts work, even if he is unable to complete the shift either through illness or injury. These may be comparatively small matters, but their effect is cumulative, and there can be no gainsaying the fact that many collieries nowadays in the South Wales coalfield find it difficult to make two ends to meet, and even the stronger concerns feel the strain. The Consolidated Cambrian, Limited, for example, have had to pay a reduced dividend of 10 per cent. instead of 15 per cent. In the case of D. Davis, whose balance sheet is out this week, and which is also one of the most flourishing concerns in the coalfield, there is disclosed the fact that the directors have had to fall back to the extent of about 10,000*l.* on the sum brought forward last year in order to make the usual distribution. No provision is made for excess profits duty—presumably for the reason that this will be comparatively very small. In view of the standing of this concern and the fact that it has an output of about 2,000,000 tons of coal per annum, it is problematic whether the Controller will be able to secure the necessary funds to make his proposed compensation scheme of any value.

Miners' Demand for Five-day Week.—Although the Coal Controller has definitely expressed himself as being averse to the proposal for a general curtailment of the working week to five days, the Executive Council of the South Wales Miners' Federation on Saturday last decided to press forward their demand. The Controller suggests that the best methods of dealing with the problem of slack time at some of the collieries is by the transference of men from pits where work is irregular to those pits which can do with more labour and also to other employments of national importance. This was the view held by the Commission which was appointed recently to investigate the matter, for in this way there would be obviated the wastage of labour involved in the systematic curtailment of the hours of working. The miners, or at any rate their leaders, seem bent upon pressing forward their proposal for the adoption of a five-day week, and probably more will be heard of the matter before long.

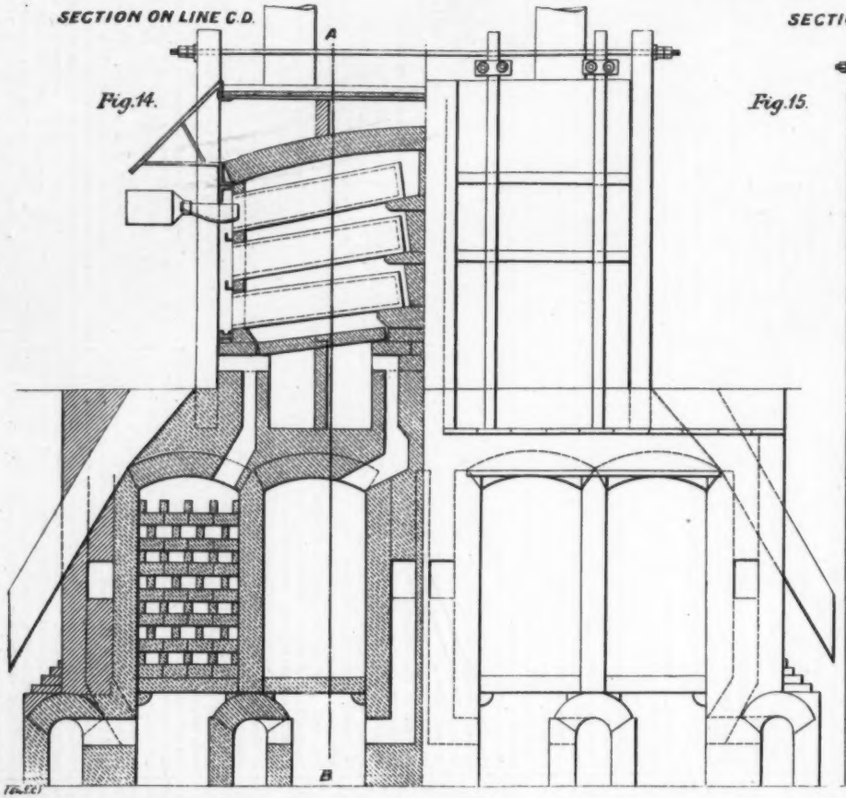
BRIQUETTING OF ANTHRACITE COAL.—An instructive paper on the way in which the difficulties of anthracite briquetting have been overcome by the Lehigh Coal and Navigation Company, of Lansford, Pennsylvania, was to be communicated by Mr. W. P. Frey to the New York meeting of the American Institute of Mining Engineers of this February, and the paper was published in advance, as is the general custom of this Institute, in the Bulletin of January last. The use of coal-tar pitch, which was discontinued three years ago, had resulted in a loss. The Dutch oil process, which has proved successful, was introduced by the General Briquetting Co., of New York; it makes use of a small heavy oil residue as binder. This oil is called hydrolyne by some companies and asphaltum by the Standard Oil Company; being itself a good fuel, it raises the calorific value of the coal by 3.2 per cent. The briquettes are not quite smokeless, but the white smoke is not considered objectionable. The raw material for the silt must not contain more than 16 per cent. of ashes to prevent clinkering, and for this reason many large anthracite culms are not directly available for briquetting. The success of the company is largely due to the new cone separators and shaking tables for preparing the silt. The average cost of making 1 ton of waterproof, tough, hard briquettes is stated to be 3.35 dols, the oil binder itself costing 1.25 dols.

DOUBLE GAS-FIRED FURNACES FOR THE DISTILLATION OF ZINC.

(*For Description, see Page* 200.)

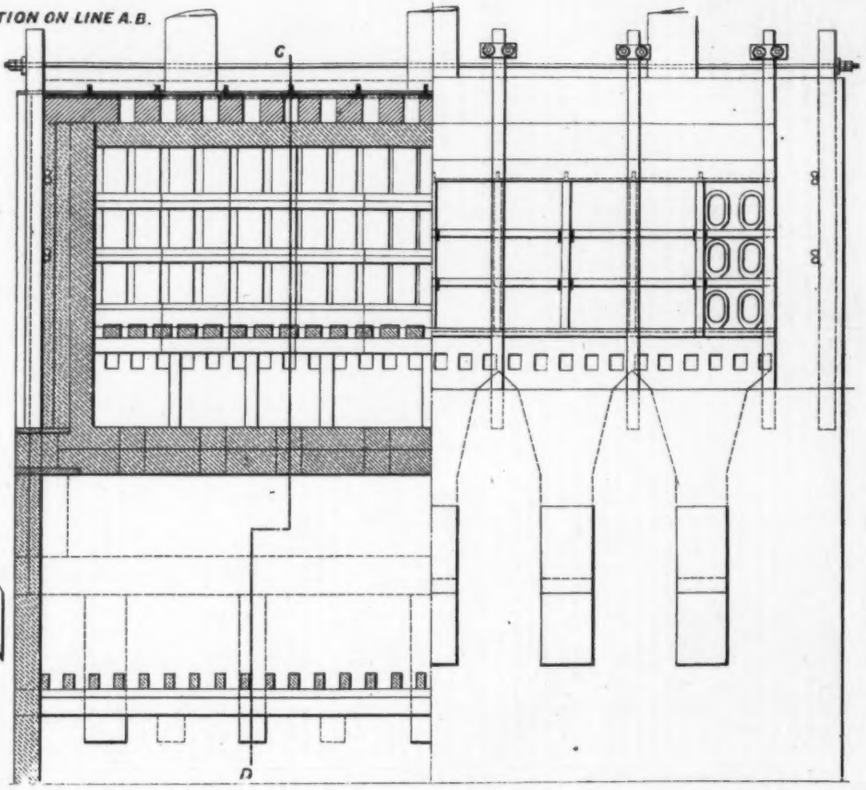
SECTION ON LINE C.D.

Fig.14.



SECTION ON LINE A.B.

Fig.15.



EFFECT OF COPPER ON STEEL.—Though the presence of copper is believed to raise the strength, there is not general agreement as to the effects of copper on the mechanical properties of the steel. Hence Professor C. R. Hayward and Mr. A. B. Johnston, of the Massachusetts Institute of Technology tested various specimens, of two steels, supplied by the Pennsylvania Steel Company (Bulletin, American Institute of Mining Engineers); the steels contained, in per cent.: C, 0.380 or 0.365; P, 0.012 or 0.053; Mn, 0.57 or 0.59; S, 0.030 or 0.048; Cu, 0.860 or 0.030. The actual copper percentage was thus not high in either case, and the low-copper steel was rather rich in phosphorus. Some of the bars were tested without heat treatment; others were heated to 765 deg. and 865 deg. C., cooled in air or quenched in water, drawn at 360 deg., 455 deg. or 580 deg. C., and again quenched. The results show a general superiority of the high-copper steel over the low-copper steel. The yield-point and tensile strength were raised by the copper, and the impact test (Charpy) gave decidedly better results. The ductility was little influenced, the elongation and reduction in area were slightly improved. The Brinell hardness number was raised, and the statement of J. E. Stead was in general confirmed that copper-steel resembled a nickel-steel.

POTASH FROM BLAST-FURNACE DUST.—In our issue of February 2, 1917, we drew attention (on page 108) to the interesting research of Mr. R. J. Wysor, blast-furnace superintendent of the Bethlehem Steel Company, on the recovery of potash from blast-furnace dust. Wysor traced the potash, which is unintentionally fed into a blast-furnace together with the iron and manganese ores and with the lime and coal, right through the furnace operations and products, and he found that the greatest loss of potash (56 per cent. of the loss) occurred in the primary and secondary washers, while 20 per cent. was lost in the slag. He was able to precipitate nearly all the dust by the Cottrell system, and found about 10 per cent. of K_2O, water-soluble, in the precipitated dust. Some of the potash combines with other material to form glass and is insoluble in water. The subject has been investigated elsewhere during the last few years, though not in so thorough a fashion, and the results of analyses of dusts and spent liquors, received from various plants in Scotland, were communicated by Professor R. A. Berry and Mr. D. N. McArthur to the Glasgow Section of the Society of Chemical Industry last October. In Scotland, the potash contents of the ores is rather lower than in England, and coal is generally used instead of coke; more dust is produced in English blast-furnaces with the stronger blasts used, while more tarry matter is produced in Scotland, and more of the potash is likely to find its way into the washers and spent liquor deprived of its bulk of tar and ammonia; the "tube cleanings" from the dust catchers form a thick crust of carbonaceous matter. In nine samples of fine dust Berry and McArthur found from 4 per cent. to 19 per cent. of water-soluble K_2O, the average being nearly 9 per cent.; there were many other oxides in the dust, as chlorides, sulphates and carbonates. The highest dust yield of any of the plants in question was 21 tons per annum; in one plant, where the fuel is coke (not coal), 300 tons of dust were obtained per annum, but the potash percentage was only 3; excluding these works, the fine dust from the coal-fed blast-furnaces of Scotland would hardly reach 100 tons a year. Stove-dust samples were received from three works only, the K_2O ranging from 6 per cent. to 8 per cent.; the coke plant gave 150 tons of stove-dust with 13.6 per cent. of K_2O, of which 7.6 per cent. were water-soluble. The 15 samples of tube-cleanings were very black, and contained from 53 per cent. to 74 per cent. of ash, which was low in soluble K_2O, up to 2.7 per cent. at the best; yet this source is important because the tube-cleanings of Scotland total to 15,000 tons annually. Fifteen works supplied spent liquor samples, two samples being taken in each case at intervals of one week. The evaporation of the liquor was greatly retarded by the tarry matter present; the yield of ashes from the liquor was low, from 17 tons up to 318 tons at the best, the total yield being 1,696 tons, but the K_2O percentage in the ashes was high, 21 per cent. to 56 per cent., the average being 33.5 per cent. The potash might be recovered from the ashes by extraction with water, or the ashes might directly be utilised as manure; the experiments were made at the West of Scotland College of Agriculture. The principal sources of loss in the potash recovery would be in the pitch and in the slag; pitch from blast-furnaces is always richer in mineral matter than pitch from coal-gas and coke plants. Estimating that in Scotland 12 companies having 17 works with 102 blast-furnaces produce by-products from which potash might be recovered, and has been recovered for several years, *e.g.*, at the Dalmellington Iron Works at Dunaskin, Professor Berry considers that 1,667 tons of water-soluble K_2O might be produced per year (viz., 567 tons from the spent liquor, 886 tons from the 11,092 tons of pitch ash, and 206 tons from the tube-cleanings) from the blast-furnaces; this figure represents only a small fraction of the 32,000 tons of potash which the British Isles require, but it should not be neglected.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, February 22, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda:—(1) "Note on the Use of Approximate Methods in Obtaining Constructional Data for Telescopic Objectives," by Mr. T. Smith, B.A. (2) "A Suggestion as to the Origin of Spectral Series," by Mr. H. Stanley Allen, M.A., D.Sc.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, February 23, at 6.30 p.m., at the Grand Hotel, Aytoun Street. A paper, on "Engineering Salesmanship," will be read by Mr. C. W. Hunt, Member.

THE SURVEYORS' INSTITUTION.—Monday, February 25, at 5 p.m. A paper, on "The Effect of Taxation on the Development of Mineral Estates," will be read by Captain (late Professor) David Bowen, R.E., Fellow.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, February 26, at 5 p.m., at the House of the Royal Society of Arts, John Street, Adelphi, London, when a paper, on "A Survey of Methods of Directing and Concentrating Light," will be read by Lieut.-Commander Haydn T. Harrison, R.N.V.R.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Wednesday, February 27 (not on Friday, February 22, as previously arranged), at 6 p.m., in the Literary and Philosophical Society's Theatre, Newcastle-on-Tyne. The following lecture will be given:—"Water Power Development in Canada," by Professor J. C. McLennan, Ph.D., F.R.S., Director of Physical Laboratory, University of Toronto.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 1, at 5.30 p.m. A discourse will be delivered by Professor Arthur G. Green, M.Sc., F.R.S. The subject is "The Modern Dye Stuff Industry." Afternoon lectures next week at 3 p.m. Tuesday, February 26. Sir Richard T. Glazebrook, C.B., D.Sc., F.R.S., M.R.I., Director, National Physical Laboratory, on "A National Laboratory of Industrial Research" (Lecture I). Thursday, February 28. Mr. Edmund Gosse, C.B., LL.D., on "Three French Moralists and their Influence on the War—Vauvenargues" (Lecture III). Saturday, March 2. Professor Sir J. J. Thomson, O.M., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "Problems in Atomic Structure" (Lecture III).

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and will include the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, FEBRUARY 22, 1918.

BRITISH AND GERMAN COMPETITION IN STEEL.

BEFORE the war Germany became the greatest exporter of iron and steel goods. What position will Germany occupy as a world competitor after the war? This is a matter of cardinal importance alike to importing countries such as the Latin Republics, and to exporters, notably Britain and the United States. A brief review of the progress and methods of German competition before the war affords a striking object-lesson in commercial economics, and gives ground upon which to base a forecast of the future. This German-made war is effecting a revolution in the world's steel trade which is likely to react detrimentally, if not disastrously, upon German industry. It is not probable that Germany will regain a leading position. On the contrary, the great bulk of the world's export business in iron steel and engineering products will probably be divided between Britain and the United States. Roughly, there was prior to the war a world's export trade in iron and steel manufactures amounting to about 18,000,000 tons a year, valued at about 200,000,000*l.*; in addition, the machinery, &c., exports were worth about 120,000,000. Of that business Germany was taking not less than one-third. In the last three calendar years before the war German exports of iron, steel and other metal goods were, in 1911, 71,000,000*l.*, in 1912, 83,000,000*l.*, and in 1913, 95,000,000*l.*; and of machinery, implements, tools, electro-technical products and conveyances, in 1911, 45,000,000*l.*, in 1912, 51,000,000*l.*, and in 1913, 57,000,000*l.* In the fifteen years preceding 1914 Germany's foreign trade in iron and steel was increased by 500 per cent., against a British increase of 50 per cent. As recently as 1900 Britain exported 3,250,000 tons in the year, against Germany's 800,000 tons. But in the last twelve months before the war Germany exported over 6,000,000 tons, against Britain's 5,000,000 tons.

Germany's progess in this line, it is of special importance to observe, was not due to any superior natural resources or geographical favours, or even manufacturing efficiency, compared with those of Britain. It was due to a system of bounties, subsidies, credits and other peculiarly German methods which are not likely to be renewed after the war on anything like the old scale. In other words, future competition will be more natural, and in that competition Britain will probably come out an easy winner. In the German steel trade there is a complete network of what are called syndicates, and these, before the war, operated a scheme of export bounties that was one of the wonders of the commercial world. And the syndicates were backed up by the German Government and banks.

To understand the German export bounty system it is necessary to note the character of industrial syndication in Germany. It reflected the military character and discipline of that nation. It must also be observed that the system differs as widely from the "trust" system of America as it does from our British individualistic methods. A German syndicate does not really own or control works, as the American Steel Trust does; it simply governs the production and sale of products. Thus a German concern manufacturing half-a-dozen different articles will be a member of the same number of separate syndicates, and not a unit of a single company, combine or corporation. There are syndicates for every important material and article of steel manufacture, from iron ore, coal and coke to plates, bars, wire, machinery, and even nails. There are also district syndicates where local conditions are of any special character. These syndicates work in great harmony. They have their own clearing houses. Their agents are spread all over the world. The syndicate may be described as the main factor in German trade. The Government itself is intimately identified with the syndicates, actually being a member of the Coal Syndicate by virtue of its ownership of a group of coal mines. The usual method of procedure adopted by a German syndicate is for its expert officials to visit periodically the works whose products are controlled, record the situation, equipment, productive capacity, and the special aptitude, if any, of each of the associated works. Orders are received by the syndicate and allotted in due proportion among the works; prices are fixed, shipments arranged, and accounts collected. Briefly, it may be said that the syndicate attends to business whilst the manufacturer looks after the efficiency of his works.

The export bounty system was inaugurated by the German syndicates in 1897. At that time Britain was exporting four times as much steel as Germany. Within twelve years Germany had drawn level with us in steel exports. That was mainly the result of bounties. The syndicates governing coal, ore, pig-iron, raw steel, &c., agreed to supply their associated customers—the steel manufacturers and engineers—with such materials, when worked up for exports at lower prices, on the rebate plan, than when the material was consumed in manufacturing for the home market. Standard prices would be fixed, but upon every ton exported or worked up into goods for export, a rebate or bounty would be paid. The coal syndicate granted rebates of as much as 4*s.* per ton, the pig-iron syndicate 10*s.* per ton, the steel syndicate 15*s.* per ton, and so on. Sometimes these rebates and bounties amounted to as much as a reduction of 33 per cent. in export prices, compared with home figures. By these means German products were sold abroad below actual, or natural, cost of production. That was really the secret of German success.

Again, the German Government rendered great service to the traders. It carried goods for export on its railways and canals at half the ordinary rates. It paid subsidies to German ships carrying German products abroad. It energetically worked its

consular and diplomatic services in the interests of its exporters.

The German banks also lent valuable assistance. They had established branches in most foreign countries, and their policy was to give the home manufacturers all possible particulars about trade openings abroad. Through their foreign branches the banks were in possession of accurate knowledge regarding foreign markets and customers, and through this channel German manufacturers obtained valuable information. For example, if a German maker of laundry machinery wished to obtain business in any important American city, he could inquire at his bank for information concerning the prospects. There he would find a perfect mine of particulars. The bank would furnish information regarding the state of the laundry business in the particular city, the number of laundries in operation, their class of work, their scale of prices, the character of the water used, the kind of machinery and labour employed, and so forth. If the manufacturer decided that the opening was promising, the bank would introduce his agent to the proper parties. If business resulted the bank would, if necessary, finance it, arrange shipment, and finally collect the account. Besides all this, the leading German manufacturers, merchants and shippers, formed special societies for nursing foreign trade in the Argentine, Brazil, and several other countries, and these societies were supported by the highest authorities in Germany. There was also a federation of these German foreign trade societies, formed chiefly for the exchange of information so that each might benefit from the experience of the others.

Now it is probable that German finances will be in such a condition after the war that the lavish subsidisation of export trade which characterised the competition of that country before the war cannot be renewed on anything like the old scale, besides which many countries will adopt special measures for the prevention of German "dumping"—that is, selling goods below cost for the purpose of ruining competitive trade. Moreover, Germany will have lost so heavily in man-power that her industrial productive capacity will be much below the pre-war level. On the other hand, Britain's capacity is increasing month by month. In Germany to-day the iron and steel works output is said to be at a rate of 5,000,000 tons per annum short of that of 1914, whereas Britain's output is at a rate of nearly 4,000,000 tons above the level attained before the war. And yet again, as a result of the war Germany will have lost certain valuable raw material supplies which the British Empire will in future reserve for its own use. A very large proportion of the materials worked up in German factories before the war was obtained from British Colonies and Possessions.

With the great improvements effected in our iron and steel trades during the war, and with German subsidised competition weakened, if not stopped, we shall be able to beat that country in exportation. To a large extent we hold the same economic advantages over Germany as we do over the United States. We have the best coal in the world, and we have our coal and iron supplies practically side by side, just as we have our steel works and shipping ports close together. In Germany both the coal and the iron ore are inferior to ours, they are deposited far apart, and the iron and steel works are at long distances from ports of shipment. Ton for ton, and quality for quality, independently of export subsidies and bounties, we can produce and ship iron and steel goods cheaper than Germany or any other country, and it will be to Britain far more in the future than in the past that the purchasers of iron and steel products will turn for satisfaction.

RESERVOIR DAMS.

It is only within very recent years that the theory of the stability of ordinary masonry dams has been put upon a satisfactory footing mainly through the ingenious experiments of Wilson and Gore. These, it is true, merely established the fact that the then accepted methods of proportioning such structures were reasonably reliable, and they did not lead to any important changes in design. The confidence of engineers in these methods had, however, been somewhat disturbed by certain papers by Professor Karl Pearson and his associates. These, although their practical utility was largely destroyed by mathematical and experimental errors, had at least the negative merit of giving rise to a general review of the whole question by those best qualified to deal with the complicated problems involved. The net result of the researches thus originated was, as already recited, to establish the sufficiency of the accepted practical rules. It is a commonplace, that once either an organism or a product of the engineers' art reaches practical perfection, it is in serious danger of being superseded by some hitherto unnoted and apparently insignificant competitor. Those who saw the fine reciprocating engines for electric power stations exhibited by certain continental firms at the Paris Exhibition of 1900 might have been pardoned for failing to realise that these marked the culminating point of labours extending over a century, and that fifteen years later a power-station engineer would almost as soon think of installing a Newcomen engine as one of these. Similarly, hints were not wanting at the meeting at which the experiments of Wilson and Gore were described, that the gravity lift of dam was to find at any rate a serious competitor in certain other forms in which less reliance is placed on the mere mass of the material used than in disposing it in the most effective fashion. Two lines of development are apparent, viz., the arched dam pure and simple, and the hollow type of dam which are a development of certain forms used years ago in America when timber was cheap and easily accessible, whilst masonry was costly and labour scarce. A number of such dams were illustrated in the older editions of Trautwine's famous pocket book.

Dam failures have so often been catastrophic in their effects that engineers who have to take the responsibility of building such structures in thickly peopled countries quite properly hesitate before departing from well-established precedents, and new types are thus developed almost wholly in unsettled areas. Arched dams have, however, now an established history of over a century, the Alum Meer dam, near Hyderabad, having been built in 1800. It is true that not many arched dams have been built since, but as Mr. Duryea pointed out in a recent meeting of the American Society of Civil Engineers, there have so far been no failures recorded with this type, whilst there have been some serious failures of gravity dams, although the number of such mishaps is no doubt a very small percentage of the total number built. This good showing of the arch type is the more remarkable in that their theory is in a far from satisfactory condition. A good many have been built in New South Wales, of which one has a height of 87 ft. These were proportioned by employing a formula which is essentially the same in form and derivation as is adopted in determining the thickness of the shell plating of a boiler. This formula leads to the absurd result that when the height is considerable the thickness required at the base may be even greater than if the dam were of the simple gravity type. Of course, the base of a curved dam cannot possibly resist by arch action, since it is firmly morticed into the foundation, and it cannot take the deformation needed to develop the arch action so long as the masonry remains intact. If, however, the simple formula used be abandoned, and the structure calculated as statically indeterminate, it will be found that very high tensional stresses exist in the up-stream face near ground level. Experience seems to show that these stresses are of no practical importance, but as they are far higher than masonry can withstand without cracking, it is, to say the least, extremely difficult to develop a really rational method of proportioning such structures. This unsatisfactory state of the theory will probably hinder the extension of the system, as the modern engineer is less content than his predecessor with rules of thumb based solely on successful experience.

Less objection on this score attaches to the hollow type of dam, which is another possible competitor with the standard type. In this case the up-stream face makes a large angle with the vertical, so as to throw the resultant of the water pressure well within the base. This up-stream face may either be a flat plate of reinforced concrete or a series of arches. Multiple arch dams of this type were described in a paper by Mr. Jorgensen, reproduced in Engineering, vol. civ, pages 183 and 224. Some divergence of view, both as to the economy of the type and its suitability for other than special conditions appeared when this paper was discussed at a meeting of the American Society of Civil Engineers. Some of the speakers maintained that the type was possible only where the foundations were exceptionally good. In fact, the author of the paper advised the use of multiple-arch dams only when the foundations were of solid rock. On the other hand, Mr. G. S. Williams stated that he had built several multiple-arch dams and in no case was the foundation of rock. He considered that if the carrying capacity of the material under the buttresses was sufficient, the type could be used safely on sand, gravel or clay foundations. As to cost, it was stated that the type was specially suitable to sites where the cost of cement ran high. Otherwise the saving in the cement used was more than offset by the cost of the forms, which necessitated the employment of skilled labour.

One drawback to the rival type of hollow dam in which the upstream face consists of a flat slab of reinforced concrete, was referred to in this discussion. Whilst good reinforced concrete has proved eminently satisfactory; every now and then, there are cases of failure due to carelessness or incompetence on the part of those responsible. No doubt these will become less frequent as experience grows and contractors realise that in this class of work the concrete is called upon to exercise other qualities than that of mere massiveness. A fraudulent reduction of the proportion of cement to aggregate which might matter relatively little in a foundation block would be absolutely disastrous in reinforced concrete where each part is carefully proportioned to take a definite and determinate stress.

Dams of the hollow type are, it is claimed, less liable to be overthrown by uplift, as it is easier to arrange for efficient drainage than in the case of gravity dams. The down-stream faces of the of the latter are often damp, showing that water is percolating through. It is commonly assumed that the pressure gradient of this percolating water is a straight line rising from zero at the down-stream side to a maximum at the up-stream face. Some interesting observations on this head were given by Mr. Duryea in the discussion on Mr. Jorgensen's paper. Mr. Duryea's observations were made on La Boquilla dam, Mexico, which is 244 ft. high. They extended over a period of twenty-two months, during which the level of the water impounded varied between 140.3 ft. and 213.6 ft. above foundation level. The pressures were measured in 39 holes provided for the purpose in the body of the dam near foundation level. The pressure gradient found followed pretty closely a straight line law, but the general slope was found to be the same as if the effective head at the up-stream face was one-third its actual value, with a corresponding reduction in the uplift. In designing the dam it was assumed, owing to the lack of definite data, that this uplift due to water leakage might be two-thirds that corresponding to the actual level of the water in the reservoir.

PROBLEMS IN ATOMIC STRUCTURE.

Following what is now a long-established precedent, Sir J. J. Thomson, O.M., P.R.S., is giving at the Royal Institution this session a course of lectures setting forth in plain language certain of the problems now confronting physicists, the means and methods by which they are being attacked and the progress made towards satisfactory solutions.

In his opening lecture delivered on Saturday last, Professor Thomson said that he proposed to consider in this series what light had been thrown, by investigations carried out during the past few years, on the structure of the atoms, on the differences in atomic structure characteristic of different elements, and on the mechanism by which one atom was united to another, to form a molecule either of an element or of a chemical compound. We would, he believed, start from

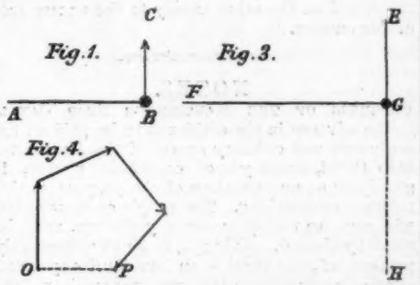
firm ground in supposing that one of the things that went to build up the atom was the electron. The electron was a small particle having a mass which was but a minute fraction of that of the hydrogen atom, and it carried an invariable charge of negative electricity. He had, he continued, often shown in that room how these electrons might be liberated by different agencies. They were, for example, given off in streams from incandescent metals. Again, if ultra-violet light or Röntgen rays acted on different substances these were also caused to emit streams of these electrified particles, the nature of which did not depend in any way on the character of the agent used or on the material from which the particles were emitted. We were thus on quite firm ground in assuming that these electrons formed part and probably a very essential part of the structure of each atom. It was natural to try and see whether we could not go further. Undoubtedly each atom possessed electrons, but how many? Could we contrive to find out in any way the number in any particular atom? How did this number vary when we passed from hydrogen to one of the heavy atoms such as gold or platinum?

It was mainly to this problem of finding the number of electrons in an atom that he proposed to devote attention that afternoon. This problem was not one that could be solved by direct frontal attack. We might, amongst the *debris* left in a vacuum tube through which an electric discharge was passed, try to pick out some atoms from which the electrons they possessed had been torn out, and it was true that in such tubes atoms were found which had lost electrons. Thus in positive ray analysis large numbers of atoms were found, which had lost one or two electrons. The loss was greatest in the case of mercury, some positive rays of which showed a loss of seven electrons.

There was, however, no reason to believe that in positive ray analysis we exhausted the store of electrons in the atoms, taking from them all that they possessed. It was therefore necessary to try and devise some other method, which would enable us to form an accurate estimate of the total number of electrons in an atom. The simplest method, and the one exposed to the fewest ambiguities, depended on measuring the effect of the little wavelets, which would be started by an electron if placed in the path of any electric wave. An electric wave consisted of electric forces propagated outwards and changing in their direction with a rapidity which depended on the character of the wave. Suppose an electron were placed in the path of a wave of this kind. Let the force in the wave be represented by the vertical line BC in Fig. 1, and the direction of propagation by the line AB. Then an electron placed at B would be moved up in the direction BC, and as the direction of this force changed so would also the motion of the electron, which would thus be waggled up and down. By this motion, it would itself become a generator of little electric wavelets, as would all the other electrons encountered by the wave. Each of these would, in fact, start little waves "on its own." If then we could determine the number of the little wavelets started when an electric wave fell on the electrons of an atom, this number would be equal to the number of electrons in that atom.

It was this method he proposed to discuss that afternoon; and he would, Professor Thomson continued, start by showing what happened when a train of waves encountered an obstacle, and would demonstrate the difference between the reflection of waves by large obstacles and by small ones. When light fell on a mirror it went off again in a perfectly definite direction. That it did so, was due to the fact that the mirror was large in all its dimensions when compared with the wave length of ordinary light. If, however, such a mirror were exposed to the waves used in wireless telegraphy which had a wave length of some hundreds of yards it would not act as a mirror at all. It would show none of that "regular reflection" observed when the radiation impinging on it was of short wave length. The phenomena observed when the obstacle was small, compared with the wave length, were, in fact, much more complicated than when the contrary was the case.

To illustrate by analogy the distinction between the "scattering" of light and its "regular reflection," the lecturer started a series of wavelets in a trough of water, the surface of which was strongly lighted and reflected with considerable magnification on to a screen. Placing a long bar of wood in the path of these wavelets, it was shown that the wavelets advanced up to the obstacle in regular lines and were reflected in the same way. Replacing this bar by a small float, the effect was quite different in character. The main wave proceeded on past the obstacle, whilst the latter on being thus disturbed set up little wavelets of its own which spread out radially in all directions the crests and hollows forming complete circles round the small obstacle as centre. In the corresponding case in optics, Professor Thomson proceeded, the light was said to be "scattered" when reflected from objects



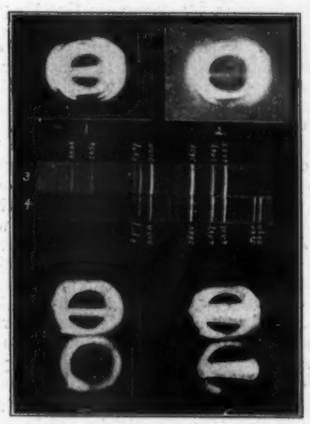


FIG 2.

which were not large in comparison with the wave length. The properties of the little wavelets then set up had been first studied by Lord Rayleigh in a paper "On the Scattering of Light by Small Particles." Lord Rayleigh had shown that the light scattered by such particles would be the more intense the shorter the wave length, so that blue light would be scattered more than red. Hence if white light were allowed to fall on small particles the scattered light would be more blue than red, and Rayleigh suggested that the blue of the sky was accordingly to be attributed to this scattering of light by numerous small particles of dust suspended in the air. He even suggested that the light scattered by the very molecules of the air might be sufficiently intense to account for the blue of the sky.

Professor Strutt (Lord Rayleigh's son) had quite recently in some most interesting experiments confirmed the conclusion that the molecules of the air were capable of scattering light. He had actually photographed the light reflected from the molecules of air from which all dust had been completely excluded. A reproduction of some of Professor Strutt's photographs is given in Fig. 2. That in the left hand top corner of the figure showed, the lecturer said, the path of a beam of light across a bulb containing perfectly dust-free air. The circle showed light reflected from the walls of the bulb; it was not scattered light, but the beam could also be clearly seen crossing the tube, so that enough light to affect a photographic plate was scattered by the air molecules. The view on the left was, he said, taken through a screen transparent to ultra-violet light. On the top right-hand corner of the figure was shown another photograph taken this time through a yellow screen. In this case, although the outer ring due to light reflected from the bulb walls was as marked as ever, practically all trace of light scattered from the air molecules had disappeared. The two views provided a good illustration of the fact that the intensity of the light scattered by small particles increased very rapidly as the wave length diminished. The scattering of the ultra violet was very strong, whilst that of the yellow light was hardly appreciable.

The same thing was shown, the lecturer continued, by the two spectra reproduced in the middle of the figure. Here the upper was the spectrum of the scattered light and the lower that of the incident light, which was furnished by a mercury lamp, of which the photograph represented the normal spectrum. Strong lines in the yellow of the incident light were invisible in the spectrum of the scattered light, and the latter showed lines in the ultra-violet which were extremely faint in the lower spectrum. The two spectra were obtained with very different exposures, so that they afforded data for comparing merely the relative strength of the lines in the two cases. They showed, however, very clearly that the "centre of gravity" of the "scattered" spectrum had been shifted a long way towards the ultra-violet.

In the lower left-hand corner of the figure were, Sir Joseph continued, two views taken through a Nicol prism. With this prism in one position the upper view was obtained, whilst the view below was taken with the nicol turned through a right angle. In this case the scattered light was completely extinguished, which proved that it was completely polarised. This was in fact a distinguishing characteristic of scattered light. If there were any question as to whether light was scattered or came from some other source, we might be sure that if it was not polarised it was not due to scattering.

The lecturer illustrated this by showing that the light scattered by the small particles produced by pouring into water a solution of mastic in alcohol was almost completely polarised and, he repeated, Tyndall's experiment in which the particles scattering the light were produced by the action of the light itself on the vapour of amyl nitrite. He showed also that light was scattered when a beam of it was passed through iodine vapour. In the experiment with mastic, he said that the particles concerned, though small, compared with the wave length of the light, were large as compared with molecules, whilst in the experiment with iodine vapour, the phenomena was more complex, since the effect observed was not due to simple straightforward reflection by the molecules.

He had, Sir Joseph continued, brought forward these examples of the behaviour of scattered light, because the same principles could be applied when particles still smaller than the molecules, viz., the electrons were concerned. Before it was permissible to assume that effects observed were to be explained by scattered reflection, certain tests must be applied. The light scattered by molecules was proved to be polarised. Was the Röntgen radiation scattered from electrons also polarised? That this was so had been proved by Barkla, who had brought forward conclusive evidence showing that this was the case with the Röntgen rays. These rays were now known to be electrical waves with a wave length much smaller than that of ordinary light, and of which the electric force accordingly changed its direction much more rapidly. Electric waves were generated by the motion up and down of an electrified body. The energy of the wave was propagated in all directions but one, no flow of energy being detectable in a direction along the line of motion of the vibrating particle. The maximum effect was observed in a

direction at right angles to this line of motion, but as stated no waves could be detected as coming to the observer along the axis of the motion. Thus if in Fig. 3 GE represented the line of motion of an electron set vibrating by the electric wave reaching it along the direction FG, a wave detector placed at H in line with GE would record nothing. Whilst if it were placed along a line perpendicular to the plane of the paper a maximum effect would be attained. Hence if it were proved that Röntgen ray effects showed a maximum in one direction, and were zero in another direction at right angles to this, it would constitute strong evidence that the phenomenon corresponded to a complete polarisation of the electric force. In actual fact, matters were not so simple. We had to deal not with one electron, but with many, vibrating in all directions normal to the path of the impinging wave. Hence whilst no effect due to an electron vibrating along the line EG would be detectable at H, there would be an effect here due to some other electron vibrating at right angles to the plane of the paper. The result was that the effect observed was constant when the detector was placed anywhere in a plane drawn through EG and perpendicular to FG. If, however, the detector were placed out in front of the obstacle it would then point along a line at right angles to the motion of all the vibrating electrons and the effect would be twice as great as if at H. A very stringent test could thus be made as to the polarisation of the wavelets generated by the electrons in an atom. Barkla had shown that the condition in question was satisfied with great accuracy, thus providing very good evidence in favour of the view that when we examined the effect of Röntgen rays on substances we had to do with wavelets started by the motion of electrons within the atoms.

The problem then arose as to how could we calculate from measurements made on these wavelets the number of electrons in the atom, or what was the same thing, the number of wavelets started. The solution of this problem involved an application of one of the most fundamental principles in physics and very generally applicable. If but one centre were in operation the problem was easy, but each electron was pretty sure to be one of a crowd. How would the disturbances from these separate centres coalesce? Would they simply add up, or was their resultant expressed by some more complicated law?

It turned out that according to the conditions either alternative might hold. If two electrons lay close together along the line of propagation of the incident wave, their resultant effect would depend upon the wave length. If the distance between the two was small compared with this wave length both electrons would be set vibrating in phase, and the amplitude of the wavelets produced would be the sum of the individual amplitudes and the energy involved would be proportional to the square of this resultant amplitude, or four times as much as if a single electron only were concerned. In such a case as this therefore, the energies were not simply additive, but the resultant value increased as the square of the number of electrons concerned.

If, on the other hand, the two electrons were far apart, the phases of their vibrations would no longer be identical, and the resultant amplitude of the wavelets generated would be, not the arithmetical sum of the individual amplitudes, but their vector sum. Thus in Fig. 4 the amplitude of each of a number of component wavelets was represented by the length of a line and the phase by the angle this line made with the horizontal axis. The resultant amplitude was then represented by the distance OP.

The phase of any component was a mere matter of chance. If all happened to have the same phase the resultant amplitude would be the simple sum of all the component amplitudes, but if the phase of each was a matter of chance the resultant amplitude might have any value less than the arithmetical sum. Lord Rayleigh had discussed the matter in a paper entitled "The Resultant of a Large Number of Uniform Vibrations of Arbitrary Phase." No objection could be taken to this title either on the score of accuracy or adequacy, but in essentials the problem was an older one, long known by a more disreputable name, viz., the "Drunkard's Walk." Suppose, for example, that at every 100 yards a pedestrian fell down, and on getting up restarted in a new and arbitrary direction. The problem was to find the distance he would have got from his starting point after a large number of attempts. Actually different men would get different distances, but if the experiment were made it would be found that with, say, 10,000 men, the results collected about a certain average value equal to the length of each journey multiplied by the square root of the number of the attempts. Were each journey one yard in length, and were 10,000 such journeys made, the average distance from the origin at which the men finished up would be $1 \times \sqrt{10{,}000}$ or 100 yards only. This result might serve to illustrate the difference between an expenditure of energy inspired by intelligence and "muddling through." In the one case the result was proportional to the number of steps taken and on the other merely to the square root of this number.

NOTES.

Progress of the Manchester Ship Canal.

The advance in the dividends to be paid on the preference and ordinary shares of the Manchester Ship Canal, small yet of consistent growth, is gratifying as an indication of the progress of this national undertaking. The people of Manchester, who came to the rescue some years ago, must be specially pleased. Although, as we have frequently pointed out, the canal is an important city asset, indirectly influencing all the industries and increasing the trade facilities, nevertheless it is satisfactory to know that the tide has turned and that the patience of the shareholders and city ratepayers is likely to be rewarded. It is true that canal rates and charges have had to be increased, but this was to meet the increased allowances granted to employees throughout the ship canal and the continually enhanced prices of consumable stores and materials. Moreover, the increase is only proportionate to that in most other great transport undertakings. The exigencies of war have resulted in a steady decrease in the seaborne traffic, the tonnage using the port in 1913 having been nearly 5,500,000 tons, whereas in 1917 it was only 3,843,324 tons, a decrease as compared with the previous year of 696,843 tons. The total traffic, including barges, in the same period decreased from 5,780,161 tons to 4,152,754 tons. Notwithstanding this, the gross receipts increased from 654,937*l.* to 861,996*l.*, the latter sum being an increase on the previous year of 30,312*l.* Some works of repair and renewal have had to be postponed, owing to the short supply of labour and material, but 20,000*l.* has been added to the reserve for contingencies and repairs, bringing this reserve up to 50,000*l.*, most of it invested in Government stock. The net expenditure on capital account was 8,732*l.*, but the gross amount was 26,611*l.*, the difference being due to the sales of land, amounting to 17,879*l.* The principal works carried out were two additional filling culverts for the 80-ft. lock at Eastham, which have been completed and are in use, and works for the extension of the wharf and railways at Irwell Park, Eccles, while considerable work has been done in the extension of refrigerated accommodation at the desire of the Ministry of Food.

Proposed Newcastle Section of the Junior Institution of Engineers.

Recently a meeting was convened at Newcastle for the purpose of inaugurating a local section of the Junior Institution of Engineers similar to various organisations in a number of the industrial centres. Mr. W. A. Tookey, the secretary of the Institution, presided. He has taken a great part in the development of the Institution and is still an important factor in its continued virility. We have consistently supported the Institution because we recognise that it is doing invaluable work. We fear, however, that in this case the procedure has not been quite correct. Mr. Tookey explained that a previous meeting had been held for the purpose of finding out whether there was any desire on the part of the members or prospective members for a North-East Coast section with Newcastle as its centre, and he also explained that there was no desire whatever to be competitive with other institutions; indeed, he went further, and stated that if the suggested local section was likely to come into conflict with existing institutions, he did not think the council would sanction the creation of such a section. This is the policy we have always commended, because there is a tendency towards dissipation of energy in connection with such organisations. We admit that the Junior Institution of Engineers occupy a field which is not altogether compassed by other technical organisations. The older and perhaps more influential institutions, however, are gradually awakening to the importance of drawing within their folds the younger or junior members of the profession, and no doubt in time will be able to provide a rostrum from which the younger members of the profession will be able to give expression to their opinions, discuss their respective experiences, and acquire that habit of public expression which is desirable in all departments of activity. Although the Newcastle meeting had been called to inaugurate a local section, the motion proposed and seconded was that "permission be asked from headquarters to form a local section of the Institution of Junior Engineers with Newcastle as its centre." An amendment to this was proposed that the meeting should form itself into a committee to confer with the existing institutions with a view of seeing whether suitable social and other activities could be obtained for their younger members. Although this was seconded, Mr. Tookey refused to accept it as an amendment for the reason that the meeting was called to decide whether a section of the Junior Institution of Engineers should be formed. Although it was undoubtedly technically correct, we regret the chairman's decision, because it may involve a conflict which is most undesirable, and we hope that the council of the Institution in London will, in the spirit of the amendment, enter into negotiations with the existing institutions in Newcastle before setting up what may be a competitive organisation.

Illusions of the Atmosphere and the Travelling Vortex.

Lecturing at the Royal Institution in the two past weeks on "Illusions of the Atmosphere," on which he had discoursed two years ago,* Sir Napier Shaw, F.R.S., director of the Meteorological Office, pointed out that no ground was so fertile in illusions as the study of the weather. The repetitions of the weather, weather phases, the influence of the moon, the significance of the barometer height—all were illusions, sometimes with the amount of truth that a first-class illusion required. Even the introduction of the weather map had given rise to a fresh store of illusions. A cyclone—the barometric "low" of the Americans—was regarded as a region to the centre of which air converged in spiral paths to rise in a continuous stream producing the rain characteristic of the cyclone, its place being taken by the air descending in the central region of an anticyclone—the "high"—and diverging thence in spiral paths. That picture was misleading, and Sir Napier devoted his lectures mainly to the very complicated dynamics of a revolving column of fluid in their meteorological aspects; his conclusions had not been published so far. The appearance of the weather map, he stated, suggested the picture of a cyclone as a column of fluid revolving about a vertical axis which had its foot in the centre of the cyclone. That was probably true, in a sense, but the axis of the cyclone was not the axis of revolution. The air might revolve like a solid spinning top, the velocities of the particles being proportional to the distances from the centre, or the velocity distribution might be uniform over the cyclone area. Assuming the latter distribution, the velocity lines would, on a disc, be concentric circles at equal distances apart; the separation of the lines was understood to be inversely proportional to the flow. When a uniform pressure field was superposed upon the whole system (spinning from west through south to east), causing

* See Engineering, March 17, 1916, page 263.

the system to travel east, the lines would become crowded in the southern portion of the disc, and the circles would turn into ellipses, parabolæ or hyperbolæ according as the velocity of translation was greater, equal to, or smaller than the velocity of rotation. On the earth's surface the velocity distribution would not be so regular; but the isobars, especially at some height above ground, should show the vortex character. As a matter of fact, the weather maps of great storms, the rainless storm that visited Cambridge on March 27, 1895, the storm of October 27, 1913, which formed a thunderstorm track straight north through Devon and Wales and had its cyclone centre far out west in the Atlantic, &c., were not at all remarkable. Thus, a fast-travelling vortex would not look like one on the map, but would be represented merely by deformations of the isobars amounting to little more than indentations. With the assumed uniform velocity distribution it was difficult to imagine a force so adjustable to each particle as to push the whole system along a certain path. That was possible, however, when the whole column was assumed to spin like a solid. When the superposed pressure field was such as to push the column to the south, the column would be transformed into a cyclone travelling east, and the spin would be about the "tornado centre," at a distance V/ω from the "cyclone centre," if V were the speed it was desired to impress and ω the rate of angular revolution. The appearance would be that of a horizontal disc floating down stream while spinning in its own plane, or of a carriage wheel which looked as if instantaneously rotating about a point on the ground whilst obviously turning about the carriage axle and advancing with the carriage. The air particles described loop-paths in entering and leaving a cyclone. The travelling cyclone was then only part of a travelling column of revolving fluid, which had three centres: the tornado centre mentioned; the cyclone centre about which the winds circulated (in irregular fashion, apparently); and the dynamic centre of the isobars. If a small whirl descended from the upper atmosphere and met a uniform pressure field, the foot of the disturbance would not be vertically underneath the whirl, but would be laterally displaced; hence the "elephant-trunk" appearance of whirls and water-spouts.

POTASH FROM GREENSAND.—The recovery of potash from glauconite (greensand) seems to be easier than from feldspar, though glauconites are not so rich in potash. Glauconites are generally described as silicates of iron, alumina, potash (about 5 per cent.), &c., containing about 50 per cent. of silicon; they are marine deposits, being the cast shells of rhizopods, and owe their green colour to this origin or to ferrous oxide; the greensands which abound in New Jersey, *e.g.*, are largely glauconite. According to H. W. Charlton, of the Kaolin Products Corporation, of New York, who recently presented a communication on the subject to the American Chemical Society, glauconites are peculiar oxidic compounds associated with silica rather than silicates. By digesting finely-ground greensand with lime and water in autoclaves at pressures of 125 lb. per square inch for 4 hours or less, he obtained a very pure potash with 77.2 per cent. of K_2O, containing about 2 per cent. altogether of silica, alumina, sulphate and chlorine, but free from iron and other oxides. This is rather surprising, considering that the glauconites are very complex; they generally contain alumina, though Charlton seems to have experimented chiefly with alumina-free materials which he, in fact, selected for this reason. When feldspar is treated as stated for the recovery of potash, much water, up to 10 times the volume of feldspar, has to be used, and that water has to be evaporated again, of course, to obtain the potash from the filtered solution; in the absence of alumina, Charlton states, only little water is required, enough to agitate the mixture. Another advantage of the glauconite is that soda is not as a rule associated with potash in it. The separation of potash and soda is laborious, but would be necessary for making a superior potash, whilst the soda would not much matter in potash to be used as manure, for instance. Charlton recovers about 80 per cent. of the available potash; the complete recovery would be uneconomical. The mineral residue is utilised for making sand-lime bricks which may be coloured by being mixed with pigments for producing tiles, &c. Sand-lime bricks are made from lime and sand and other materials by the action of steam, but they do not always fill the moulds well, nor weather well, and are apt to crumble. The residue from the potash treatment has, according to Charlton, valuable annealing properties, and forms good bricks even when mixed with 60 per cent. of sand. In this respect feldspar is superior to glauconite; for good feldspars yield a smooth marble-like brick of milky appearance, whilst the glauconite residue is described as light green and not quite so good a cementing material.

LITERATURE.

The Theory of the Submarine Telegraph and Telephone Cable. By H. W. MALCOLM, M.A., Ph.D., D.Sc. London: "The Electrician" Printing and Publishing Company. [Price 18s. net.]

THE author states that this volume is the outcome of a desire to understand the phenomena which underlie the working of the submarine cable. He could not find among the many treatises devoted to the manufacture, laying and maintenance of cables any adequate explanation of the principles of telegraph transmission, apart from the work of Heaviside, who approached the subject entirely from the theoretical side. The results of his acquired knowledge, as well, we imagine, as those of much previous study, appeared serially in *The Electrician*, and these articles, enlarged and methodically arranged, are now collected in book form to afford to others the facilities which were found wanting. A large class should welcome this collection, for it is only by the study of such principles that a clear insight is gained, and from which practical advances can be made. It may be easy to follow methods sanctioned by long usage, but to make progress requires accurate knowledge based on fundamental truths. Moreover, the practical man is beginning to admit that pure science is not without some value, and he is even growing tolerant of mathematical formulæ.

The book is conveniently arranged in five sections. In the first is indicated the amount of mathematics that will be required to appreciate and follow the methods employed. Remembering how much wireless telegraphy and the transmission of energy by polyphase currents owes to the theory of imaginary exponentials, and the important part that harmonic analysis of the Fourier type plays in the treatment of periodic phenomena, no one will grudge the few pages devoted to imaginary quantities and development in trigonometrical series. Similarly, familiarity with definitions and conventions is necessary before starting on the real subject, which the author opens by a chapter on transient and periodic phenomena, giving an opportunity of emphasising the difference between the requirements of telegraphy and telephony. The telephone engineer can afford to neglect the transient phenomena which accompany the switching in and out of the periodic transmitting E.M.F. Telegraphy, on the other hand, is exclusively concerned with transient phenomena. The difference is important. The attempt to apply elementary transient theory to telephony is responsible for retarding the progress of long-distance telephony, while the application of periodic theory to telegraphy, if it is practically less harmful, leads to misconception and confusion of thought.

The telephone cable is first treated: the telegraphic equation being derived and solved for purely periodic E.M.F. The objects and methods of loading cables—a process that has been of supreme importance in telephony—are well described, and the remarks on distortion and attenuation demonstrate not only the practical character of the book, but strike the keynote of the theme that it is one main object of the author to emphasise. The introduction of practical examples founded on actual working cables is another welcome feature. The derivation of the telegraphic equation and its solution for transient phenomena, as deduced by Lord Kelvin, together with the consideration of the more generalised form of the "K.R." law, are reserved for the next section. The fundamental problem is that of determining the state of the cable and of auxiliary apparatus connected with it at any point of time after an electric charge has been impressed on one end of the conductor. Particular cases of this problem have been given from time to time, and cables have often been considered under conditions that do not occur in actual practice, recalling some of those ingenious problems so dear to the mathematical mind, in which one is invited to deal with frictionless pulleys and weightless particles. Mr. Malcolm faces the difficulties boldly, and offers a complete mathematical and numerical solution of the general problem under practical conditions. Ever-changing detail in these will call for modifications to suit a particular case, but by following the theory here indicated a reliable solution may be found for many problems to which the only answer hitherto has been furnished by experience, and often, costly experience. The more important problems brought under notice show how "to find the arrival and sending currents and voltages with various arrangements of apparatus, to derive the theory of the inductive shunt, the theory of leaks, of inductive leaks, and of the cable with continuously distributed leakance, and to extend the K.R. law to include the signalling apparatus."

The author is leading up to the important point of securing greater speed in signalling, and consequently increasing the industrial value of a cable. On this ground his fourth section, devoted to methods of signalling, is of high interest, both theoretically and commercially. To the uninitiated the problem may not appear to differ from that on a land telegraph wire, where the speed depends upon the sending and receiving apparatus entirely. But practically in submarine work, an attempt to increase the speed of transmission without necessary precautions will only make the messages indecipherable at the receiving end. In long-distance transmission, when the speed is forced, the signal is spread out and rounded off, entailing a loss of legibility. Hence the necessity of a rigorous examination of the form of the elementary arrival curve when a signal, as a dash or dot, is transmitted. The analysis of the siphon recorder results is very illuminating in this respect, and the many diagrams most instructive. In this form the dot and dash of the Morse code are retained, but the dots and dashes are of equal length, distinction being ensured by the use of opposed polarity. In sending the three dots indicating the letter S, for example, the arrangements under ordinary circumstances are such that just as the motion, positive in direction, caused by the first dot is diminishing, the second arrives, running like a wave on the top of the first, closely followed by the third. If no more signals come through, the current would pass through zero and become negative. The arrival of the first dash, say the combination in the letter O, having an opposite or negative polarity, is superimposed on the negative current, and the same process is repeated as before, but in the opposite direction. The time required by the siphon recorder to transmit legibly the six signals and spacing is 1.28 seconds, whereas in the Morse the same combination would require 1.76 seconds, a saving of nearly 50 per cent. In order to shorten the time of sending, as well as to accommodate the combination of land and submarine cables, various devices have been proposed, exhibiting considerable ingenuity. Variation in the E.M.F. seems to offer advantages, and the author's simple suggestion of giving to each signal in a letter the best theoretical shape looks hopeful. For example, in sending three successive like signals, the first could be slightly shortened and the second lengthened, so as to compensate for the distortion introduced in transmission, and making the signals equal in length and spacing. This improvement could be effected by punching out the letters on the tape not uniform in size, but of appropriate shape.

In any of these methods the sending E.M.F. is always derived from a battery, but an alternative plan has been proposed of replacing the battery by an alternator, inserted between the cable end and earth, giving a sinusoid E.M.F. of low frequency. The mechanism is somewhat intricate, but Mr. Malcolm regards such a plan as furnishing an ideal source of transmitting E.M.F., and one calculated to throw light on the phenomena accompanying the switching on and off of alternating currents in long cables. The author expresses the hope that the modifications contending for public favour will result in a systematic and exhaustive investigation, in order to determine the best sending conditions for transmission. With this hope we would respectfully associate ourselves.

In the following and concluding section the author discusses the chances of future progress in cable telegraphy in face of the strenuous competition radio-telegraphy is likely to offer. How far there is room for the two systems is open to question, but if the wireless form of transmitting intelligence had been in operation half a century ago, cable

telegraphy would not have been exploited, and the struggle to maintain its supremacy will be severe. The possibility of holding its own depends upon its power to minister in a still greater measure to the needs of the public, and an opinion is held by competent authorities that the future has little in store for submarine telegraphy save further refinements in existing practice and modifications in detail. The author does not consider that a gloomy outlook is justified, and those who think that true science never culminates, but always advances, will agree with him. He makes a very thorough and critical examination of the commercial value of a cable, as measured by its carrying capacity, based on the mathematical theory of cable phenomena, and suggests that it is not impossible but that the recognised "K.R." law, of which mention has been made, is responsible for the view that generic improvement may not be anticipated. This law indicates that the rate of signalling will depend upon the product of the resistance and the capacity of the cable. Consequently steps have been taken to reduce the resistance by increasing the weight of copper, and with it, necessarily, the amount of insulating coating, till the cost becomes prohibitive, and little hope is to be entertained in this direction. On the other hand, it is possible that a substitute for gutta-percha will be found. Such a substitute might act as beneficially as increasing the copper, but adherence to conservative methods seems to stand in the way of any new departure.

Some increase of speed without loss of legibility may be expected by improving the form of the arrival curve. The so-called "curbed" signalling, in which an opposing impulse follows close in the wake of the original signal, is used to sharpen the curve and damp the "tail." This method may be further utilised, but seems near exhaustion. Mechanical devices such as magnifying relays, characterised by extreme sensitiveness and high capacity, are not without their drawbacks. The duplexed cable readily suggests itself as a possible alternative, but the author's conclusions do not favour its adoption. "The shape of the arrival curve in the duplexed working may be slightly better or worse than in simplex working" is his verdict, "but its height is invariably reduced in the most favourable case to one-half the simplex curve." This does not condemn the duplex method entirely, because the shape of the curve is of more importance than its height, or in other words, the essential quality in legibility depends upon the rapidity with which the ordinates increase or diminish.

There is, however, another road which is not yet fully explored. A loaded cable can be made free from distortion, and a distortionless cable would transmit signals at any speed, provided the cable constants remain constant. The price paid for lessened distortion is increased attenuation. It might happen that when distortion disappeared the current became so weak as to fail to actuate the receiving apparatus. But with judicious loading this is not likely, and in any case with very sensitive recorders there might be a compromise. This mathematical theory certainly opens a hopeful prospect for mechanical experiment, and points to amendment as much in the form of the transmitted signal as in its more certain detection at the receiving end. Undoubtedly, mechanically, there are great difficulties in loading a submarine cable successfully, but the same objection was urged in the case of telephonic wires, where, however, the principle has been efficiently employed. Ocean telegraphy is fighting for its existence, and cannot afford to refuse a weapon because of the difficulty of wielding it. If the obstacles of distortion and attenuation are removed, the advantage of a metallic conductor in guiding and localising the transmitted energy will make it the favourite means of telegraphic communication.

Technical Handbook of Oils, Fats and Waxes. By Percival J. Fryer, F.C.S., and Frank E. Weston, B.Sc., F.C.S. Vol. I. Chemistry and General. Cambridge: The University Press. [Price 9s. net, bound.]

Both the authors are on the professional staff of the Polytechnic in Regent-street; Mr. Fryer describes himself also as soap and glycerin works manager. Their treatise has been designed primarily for the needs of the technical worker, works chemist and others interested in the technology of oils, fats and waxes. That is a very praiseworthy object, and the book is undoubtedly very useful in many respects. The way in which the authors have approached their particular object is too well expressed, however, we are afraid, by the words of the preface: "It has been the experience of the authors, extending over several years, that, in the case of technical men generally, there exists a wide knowledge of the practical issues of the subject concerned, side by side with much ignorance of the basic principles underlying such issues." On page 1 the reader is introduced to the symbols H, C, O, and is informed that, compared with many other industries, the chemistry of the operations in connection with oils, &c., is remarkable for its simplicity. A few lines further on he is confronted by a constitutional formula of the carboxyl group characteristic of organic acids, with single and double links. There follow pages of formulæ and brief notes on the chief chemical compounds of these bodies, pointing out the possibility of the existence of several different compounds of the same formula; but the meanings of isomerism and of double links and valency are not explained until the general properties have been discussed. Those pages will hardly help the technical worker. The explanatory footnotes of foreign words are quite in place; but what is the good of a footnote on alcohol: arabic, *al* = the, *kohl* = stibium = sulphide of antimony; or on ethereal: Latin, *æther* = Greek, *aither* = the sky, from Greek, *aitho* = to burn? A few words would have made the footnote really explanatory. There is an odd misprint on page 9, by the way: *forma* (instead of *formica*) = an ant. On page 79 the substance glycerin—the authors' spelling, glycerine, has long been discarded by British chemists—is reintroduced under the modern chemical name glycerol; it should have been said that the two names concern the same substance, which is also known as glycyl or propenyl aclochol.

What is said of the iodine value is quite acceptable, though we should speak of the Huebl-Wijs rather than of the Wijs-Huebl determination, since Wijs modified the method of Huebl; what we miss is the plain statement that the iodine value indicates the per cent. of iodine-chlorine absorbed by an oil or fat, expressed in terms of iodine. Similarly there is no definition of saponification value: the number of milligrammes of caustic potash required for the complete saponification of 1 gramme of the oil or fat. Again, n^D is introduced in the remarks on refractive index without any definition of the index and of the n_D; that the figures marked Z.B. refer to the Zeiss butyro refractometer may be understood, but it is not said. Flash-point and viscosity tests are mentioned. As regards viscosity, we have Poiseuille's formula and tables on 100 η; but the works analyst does not determine 100 η, and the reader should be definitely told what the apparatus really measure, though he is informed that the viscometer times the rate of flow of a certain volume of the liquid through a standard orifice. We do not expect to find detailed guidance as to the performance of these tests in the volume, but definite references should have been given.

The authors are rather fond of subdivision and of repeated classification. When they come, with page 91 of a volume of 278 pages, to the classification and brief description of oils, fats and waxes, however, their arrangement enables them to present a good deal of information in a lucid and instructive way. Oils and fats are distinguished as of vegetable or of animal origin; all true fats and oils are glycerides, *i.e.*, esters (salts) of the fatty acids and of glycerol, and they yield glycerol on saponification. Scientifically the distinction of animal and of vegetable fats and oils is justified, because the former contain cholesterol (the commercial lanolin), a substance of not quite settled constitution, and the latter the similar phytosterol. Waxes are also esters of the fatty acids, but not glycerides; mineral waxes are simply hydrocarbons; some so-called waxes are really fats. Essential oils differ from all these bodies in composition, chemistry and uses; they are not dealt with in this book, with the exception of resin (colophony) and turpentine, which are prepared from oleoresin, a substance which resembles the fixed (non-volatile) oils. Messrs. Fryer and Weston characterise each group and then describe a typical representative, menhaden oil, *e.g.*, as typical for the marine oils, lard for the animal fats, &c.; descriptions of the other members of the group follow. In each case we have notes on character (colour, taste, &c.), physical and chemical data as determined by the 15 chief tests applied, in tabular form; special tests, chemical composition, adulteration, sources, preparation, refinement and uses. The study and identification of the properties is facilitated by the coloured diagrams, a somewhat novel feature. Each of these diagrams exemplifies one property, *e.g.*, the iodine value; the different groups of substances are distinguished by different colours and shadings, and the length (or height) of the ordinate tells us that the iodine value of olive oil has a short range between 80 and 90, whilst that of Japan fish oil may vary between 125 and 180. To prevent confusion by overlapping, the ordinates are drawn to different (arbitrary) abscissæ. While Chinese wood oil and wool wax overlap as to the bromine thermal test, they are quite apart in density. The diagrams on saponification, titre test and refractive index facilitate further distinction. The section on the production and refinement of the substances, which is illustrated by text figures and by 36 photographic plates of machines (mills, separators, decorticators, digesters, &c.), brings further welcome general information; the hydrogenation of fatty oils is also noticed in this section. The illustrations might be more fully explained; but that would have meant a considerable enlargement of the volume.

BOOKS RECEIVED.

Annual Report of the Governor of the Panama Canal for the Fiscal Year ended June 30, 1917. Washington: Government Printing Office.

The British Engineering Index and Buyers' Guide. A Key to the Products and Firms in the Engineering and Allied Trades. Compiled by F. J. Turquand, F.R.S.A., and other specialists. London: E. T. Heron and Co., Limited, 9, Tottenham-street, W. 1. [Price 10s. 6d. net.]

The Electrical Engineer's Diary, 1918. For the use of Consulting Engineers, Architects, Electrical Contractors, Central Station Engineers, and all users of Electrical Apparatus. Tenth year. Edited by J. H. Johnson. London: S. Davis and Co., 30 and 31, St. Swithin's-lane, E.C. 4. [Price 6s.]

Kinematics of Machinery; A Text-Book of Mechanisms and their Properties, with many Practical Applications for Engineers and for Students in Technical Schools. By Arthur Warner Klein, Leigh University. London: Hill Publishing Company, Limited. [Price 10s. 6d.]

Britain's Heritage of Science. By Arthur Schuster, F.R.S., and Arthur E. Shipley, F.R.S. London: Constable and Co., Limited. [Price 8s. 6d. net.]

Annuaire pour l'an 1918, publié par le Bureau des Longitudes, avec les Notices Scientifiques. Paris: Gauller-Villars et Cie. [Price 2 francs net.]

Short Logarithmic and other Tables. By W. Cawthorne Unwin, F.R.S., LL.D. Sixth edition. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain.

Resistance of Air. By Lieutenant-Colonel R. de Villamil. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 7s. 6d. net.]

Warming Buildings by Hot Water. By Frederick W. Dye, M.R.I. Second edition, revised. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 10s. net.]

Comment Economiser le Chauffage Domestique et Culinaire, notions pratiques recuillies et Publiées. Par R. Legendre et A. Thevenix. Paris: Masson et Cie. [Price 25 francs.]

Western Australia; Geological Survey. Bulletin No. 60. *General Index to Reports, 1870–1910.* Bulletin No. 63. *The Geology and Mineral Resources of the Yilgarn Goldfield.* Part II; *The Gold Belt South of Southern Cross.* By T. Blatchford, B.A. With Petrological Notes by R. A. Farquharson, M.Sc., F.G.S., and Mineralogical Contributions by E. S. Simpson, B.E., B.Sc., and A. J. Robertson, M.Sc. Bulletin No. 666. *The Geology of the Country to the South of Kalgoorlie (Coolgardie and East Coolgardie Goldfields), including the Mining Centres of Golden Ridge and Feysville.* By C. Sidney Honman, B.M.E. All issued under the Authority of the Hon. P. Collier, Minister of Mines. Perth: F. W. Simpson, Government Printer.

The Aims of Labour. By the Rt. Hon. Arthur Henderson, M.P., Secretary of the Labour Party. London: Headley Brothers, Kingsway House, W.C. 2. [Price 1s. net.]

A Short Course of Elementary Mathematics and their Application to Wireless Telegraphy. By S. J. Willis. London: The Wireless Press, Limited, Marconi House W.C. 2. [Price 3s. 6d.]

THE PHYSICAL SOCIETY OF LONDON.

THE annual general meeting of the Physical Society of London was held on February 8, 1918, at the Imperial College of Science, Professor C. V. Boys, F.R.S., president, in the chair. The annual report of the council was taken as read. The treasurer's report was read by Mr. W. R. Cooper, and both reports were unanimously adopted. Votes of thanks to the honorary auditors, the officers and council, and the governing body of the Imperial College, were carried unanimously. The scrutators (Mr. J. Lister and Mr. A. W. Grace) announced that the officers and council for the ensuing session as proposed on the balloting list had been unanimously elected. These are :—

President : Professor C. H. Lees, D.Sc., F.R.S. Vice-presidents (who have filled the office of president): Professor G. C. Foster, F.R.S. ; Professor R. B. Clifton, M.A., F.R.S. ; Professor A. W. Reinold, C.B., M.A., F.R.S. ; Sir W. de W. Abney, R.E., K.C.B., D.C.L., F.R.S. ; Principal Sir Oliver J. Lodge, D.Sc., F.R.S. ; Sir R. T. Glazebrook, C.B., D.Sc., F.R.S. ; Professor J. Perry, D.Sc., F.R.S. ; C. Chree, Sc.D., F.R.S. ; Professor H. L. Callendar, M.A., F.R.S. ; Professor A. Schuster, Ph.D., F.R.S. ; Sir J. J. Thomson, O.M., D.Sc., F.R.S. ; Professor C. Vernon Boys, F.R.S. Vice-presidents : Professor J. W. Nicholson, M.A., D.Sc., F.R.S. ; Professor O. W. Richardson, M.A., D.Sc., F.R.S. ; S. W. J. Smith, M.A., D.Sc., F.R.S. ; W. E. Sumpner, D.Sc. Secretaries : W. Eccles, D.Sc., City and Guilds Technical College, Leonard-street, E.C. 2 ; R. S. Willows, M.A., D.Sc., the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. Foreign secretary : Sir R. T. Glazebrook, C.B., D.Sc., F.R.S. Treasurer : W. R. Cooper, M.A., B.Sc., 82, Victoria-street, S.W. 1. Librarian : S. W. J. Smith, M.A., D.Sc., F.R.S., Imperial College of Science and Technology. Other members of council : H. S. Allen, M.A., D.Sc. ; Professor E. H. Barton, D.Sc., F.R.S. ; C. R. Darling, F.I.C. ; Professor G. W. O. Howe, D.Sc. ; D. Owen, D.Sc. ; C. C. Paterson ; C. E. S. Phillips, F.R.S.E. ; S. Russ, M.A., D.Sc. ; T. Smith, B.A. ; F. J. W. Whipple, M.A.

The president announced that Dr. R. S. Willows, M.A., was resigning his secretaryship, on leaving London for a post in the North. The council had appointed Dr. H. Stanley Allen, M.A., in his place. At the conclusion of the general business, Professor Boys vacated the chair, which was taken by his successor, Professor C. H. Lees, F.R.S.

A paper on "*A Recording Thermometer*" was read by Professor C. V. Boys. This instrument was designed and constructed to go into the case of a regulator clock. The thermometric element consists of a rod of ebonite within a glass tube. The differential expansion is determined by a pair of levers giving a movement of 1 in. for 10 deg. F. The drum carries an ordinary barometer chart, and is driven at such a speed that a 2-hour interval of $\frac{1}{4}$ in. is passed in 24 hours. The drum is driven by friction by means of a cord from below the driving weight of the clock by an $e^{\mu\theta}$ arrangement, in virtue of which when the clockweight descends the drum turns, but when the clock is wound the drum remains at rest. The instrument is designed with a view to easy construction and accuracy. It is extremely rigid, and much more magnification might be used. An alternative design on the same lines to go into a recording pantagraph is also given.

Discussion.—Mr. C. C. Paterson said that for certain purposes a quick-acting sensitive recording thermometer was very useful. What was the time lag of this instrument in taking up the temperature of the surroundings ?

Professor Lees asked how the ebonite behaved as regards constancy.

Professor Boys, in reply, said that for his purpose the thermometer was desired to be slow and sluggish, so as not to take up every trifling variation of temperature due to people entering the room. To make it quick-acting, a thin strip of ebonite would have to be used, and the glass tube should be replaced by a stout glass rod or plate some distance from the ebonite. As regards constancy, he could only speak for the three months that the instrument had been in use. There had been no signs of variability in that time.

A paper, entitled "*The Primary Monochromatic Aberrations of a Centred Optical System*," was read by Mr. S. D. Chalmers, M.A. The paper describes approximate methods of treatment of the first order aberrations of a centred optical system. Two methods are used, one primarily suited to the case where the separation of the surface is small, and the other more suited for use where the separations vitally affect the design.

The aberrational defects are expressed as lateral aberrations, *i.e.*, as defects measured in the focal plane of the system. The procedure adopted is to express the aberrational defect of a single surface in terms of the constants of the surface, and the perpendicular distance of the ray considered from the centre of curvature of the surface. The value of this perpendicular can be expressed in terms of the co-ordinates of the ray in any chosen medium, and thus the aberration due to each surface can be expressed in terms of the co-ordinates of the chosen ray, in such a way that the aberrations of the individual surfaces can be summed.

Discussion.—Mr. T. Smith congratulated the author on his paper, which he considered an interesting and valuable addition to the existing discussions on optical aberrations. He had himself used a similar reference system in dealing with this subject, but in place of a partially geometrical discussion had preferred to use a purely analytical method. The geometrical treatment was obviously advantageous in giving an insight into the mysteries of aberration to students, but it was very difficult to be certain that every contributory cause had been considered. The results stated in the paper were correct, but he was not clear that one possible contributory cause, which happened to this approximation to give a zero contribution, had received adequate consideration. If in a system of refracting surfaces at some intermediate theoretical image plane an aberration δy were present, the corresponding effect in the final image plane should not be assumed to be $m\,\delta y$, where m is the first order magnification which the image subsequently undergoes. The exact co-ordinates to the second approximation $y + \delta y$, and the exact magnification to the same order $m + \delta m$ should be considered, so that the final co-ordinates to this order are $m\,y + y\,\delta m + m\,\delta y$. It can be shown that when all the surfaces are taken into consideration the contribution of the type $y\,\delta m$ is zero. He thought that the paper could with advantage consider this point more fully. An interesting question which arose in connection with the analysis of refraction into displacements according to the ordinary laws of geometrical optics with aberrations superposed, related to the limits within which such a procedure was justifiable. The ordinary laws could only be taken as a possible first approximation for all rays for refractive indices exceeding 3. Instead of an incident angle in air of a right angle, the first approximation might only be used up to an incident angle of $\cos^{-1}\frac{3-\mu}{2\sqrt{2}}$. As the index fell in value the range over which the approximation held became less, and in the limiting case, when $\mu = 1$, the range was from 0 deg. to 45 deg. compared with the range 0 deg. to 90 deg. over which refraction took place.

Professor Lees said that these methods appeared to start off from the approximate assumption that the image of a plane was a plane. Did not this lead to errors comparable with those which were being dealt with ?

Mr. Chalmers replied as follows : The criticisms made by Mr. Smith are not, I think, justified, because the terms to which he refers do not arise in the method of treatment adopted. In transferring the aberration to the last medium it is permissible to multiply by the paraxial magnification since the actual point of crossing the object plane is transferred to the image plane by multiplying its co-ordinates by the paraxial magnification, and adding aberrational defects for this surface for the actual ray. This aberrational defect is expressed in terms of the modified values of the co-ordinates, but as the modifying terms are multiplied by the small aberrational terms this introduces terms of higher order only. If it be necessary to consider terms of higher order, it would be necessary to take them into account in expressing values of the p's in terms of the co-ordinates in the initial medium.

Mr. Smith's remarks on limits to which approximation could be applied are very interesting ; they show that approximations are justified in practically all cases which arise, except for a few cases of refraction at plane surfaces, and in this case the term he quotes is multiplied by a zero curvature.

NEW LECTURESHIP IN INDUSTRIAL MANAGEMENT.—A group of large firms engaged in the principal industries of the Manchester district have offered to the governing body of the Manchester School of Technology the sum of 3,000*l.*, spread over a period of five years, towards the cost of establishing a new department of industrial management. A lecturer is to be appointed for this period of five years at a salary of 600*l.* to conduct research in the subject, to organise the new department, to lecture to members of the university and to the public, and to assist industrial concerns in the solution of management problems.

THE YORKSHIRE ELECTRIC POWER COMPANY.—The annual meeting of the company was held last Tuesday in Leeds. Mr. A. G. Lupton, the chairman, presided, and gave interesting information on the development of the company's business. The first generating units installed were three turbines, each of 1,500 kw. ; larger units have been put down as required, and to-day a turbine of 6,000 kw. is running on load. A duplicate set to this is being erected. In the course of a few weeks, the company will have 26,500 kw. running at the Thornhill and Barugh stations, in addition to the 4,500-kw. plant from which they obtain current to supply the eastern portion of their area and which they hope before very long to see connected up to their general system of mains. The company has laid down 358 miles of mains running over a considerable part of their area ; they have 120 sub-stations or distributing stations.

THE LATE MR. J. A. MCKIE.—We regret to learn of the death of Mr. James Archibald McKie, of Messrs. McKie and Baxter, engineers, Govan, which took place on the 16th inst. at the residence of his sister, at Auchencairn, Kirkcudbrightshire, where he had been for six months. He was the third son of the late Mr. James McKie, of Bargaly, M.P. for Kirkcudbright. After his education at Malvern College, he served an apprenticeship in engineering at the Fairfield works, Govan, and added to his experience by sea service, qualifying for a first-class engineer's certificate. Later he was for a time in South Africa, and finally joined his old friend, Mr. P. MacLeod Baxter, in establishing the firm of McKie and Baxter, which, at the Copland works, Govan, has achieved a large measure of success, principally in marine engineering. At the outbreak of war he, with characteristic patriotism, gave his steam yacht "Foam" to the Government, and she has since served as an armed patrol ship. Mr. McKie was a member of the Institution of Engineers and Shipbuilders in Scotland, and was greatly respected by a wide circle of friends.

"THE SINS OF THE CAPITALIST."

TO THE EDITOR OF ENGINEERING.

SIR,—I welcome your leading article in your issue of February 8, as although it is impossible to agree with many of the conclusions you put forward, it opens your columns to a discussion of the subject opened by Mr. Hichens in his address to James Watt Society, which is almost bound to lead to lasting benefits.

You state that only an astute investor could have placed 100,000*l.* in an engineering concern at the beginning of this century and have obtained 6 per cent. return upon his investment. One is almost forced to agree ; but that is no argument against preventing such astute investor from obtaining, say, 20 per cent. upon his investment, as he could and, in cases, did do. Neither is one constrained to contest your assertion that it is doubtful if engineering limited liability companies on the average paid 6 per cent. on invested capital before the war.

From the remainder of your argument one is forced to the conclusion that the wages bill which these companies had to pay plays an overwhelming part in preventing such concerns from earning a legitimate profit, and that as Mr. Hichen's proposals are aimed at in the first instance in obtaining a greater distribution of the results of manufacture, the result will be disastrous for the engineering trade.

I do not think that there is any justification for such a conclusion. First, I think you will find in going more closely into matters that the cost of the raw materials used in the production of all machinery has far more to do with the profits that an engineering company might earn than much scraping at the wages of the trade worker.

Coal, iron, copper—the prices paid for these were such that to the investor in these concerns interest on the capital invested has been paid to amounts that have been exceedingly handsome, if not, in the light of reflection, altogether excessive. I could, of course, point to other undertakings whose operations contributed to the depressed condition of the engineering trade as a whole during the last fifteen years and who paid high interest on the capital invested, but these will suffice for the moment.

The second point which I should like to make is that you seem to assume that increased wages mean increased cost. If you had read Mr. Hichen's address in any other than a highly critical mind you would have noted that the additional wages which are to be distributed are to be used in such a manner that they are earned upon productive results.

For years before the war it is now freely admitted that restriction of output was the studied policy of the operative. Some employers still nurse the delusion that they controlled their workshops during this period. If any did it was only partial control, and the majority had almost been reduced to powerlessness. A more disastrous policy for the capitalist, worker, or nation can hardly be conceived, yet the reason for the adoption of such a policy was largely, if not entirely, in the fact that the worker did not share in the result of putting out his best. In many cases it is a regrettable and admitted fact that such a policy was directly encouraged by the action taken in certain factories where payment by results had been established of deliberately cutting the times fixed for work when it was thought the operative was earning "excessive" wages.

I have read Mr. Hichen's address over and over again, and can find no reason for your cynical treatment of the views he has expressed except in the fact that he announces a new policy and as usual with such in this country it will be hotly opposed until the sound humanity of its teaching is understood. For sound it is, and that is certain because it is only by increased productive results per head of population, which can only be successfully obtained by a system which will enable the workers to fairly share in the benefits to be derived, that this country can hope to maintain a position among the competing nations. It is the first expression by an important leader of industry of the true lesson of national brotherhood which so many hope for as the reward of these years of bitterness. You began your article, I think, on quite a wrong assumption, namely, that Mr. Hichens was addressing only the engineering world. I think if you will take the trouble to re-read his address you will find that it is laid on a much higher and broader plane—in fact, I am convinced that only by following and working out our industrial future on such lines as he lays down is there any hope for the maintenance of the trade of the Empire when international commerce takes the place of international strife.

Yours faithfully,

VAL. B. STEWART.

Junior Carlton Club, Pall Mall, S.W.,
February 18, 1918.

[Our correspondent does us less than justice when he speaks of our "cynical treatment" of Mr. Hichen's views. We certainly had no intention of treating his theories otherwise than seriously. Every one must sympathise with Mr. Hichen's aspirations, but at a time like this, when action must be taken without delay, it is quite reasonable to ask how the aspirations can be applied to practice. For instance, he said, "Possibly we, too, should pay less attention to the pursuit of pure reason—should think less in the head and more in the heart—for it may be that the solution of this industrial problem, which is by far the greatest we are called to meet, lies beyond mere intellectual and legal formulæ, beyond all economic laws and doctrines, and depends on our attitude towards social existence—in plain terms, on our moral code." Again, "The great problem of life is to reconcile the contradiction between our social and individual instincts, and it is according as their citizens succeed or fail that States rise to greatness

or decay." No one will object to these statements as ideals, the difficulty is to apply them in such a way that the result shall not be a decrease, rather than an increase, in the sum of human happiness. Mr. Hichens went on to indicate some of the practical conclusions. They were: (1) "That no business is entitled to make unlimited profits"; (2) "The reward of labour must in the last resort be determined by the State"; (3) "The status of labour as a whole should be raised"; (4) "The hours of labour should be reduced"; (5) "Drastic economies in production and increased output are needed." Now each of these would furnish a text for many articles, and we confined ourselves to the first and second. As to the first we pointed out that as far as engineers are concerned, and we cannot claim to speak for other industries, profits, so far from being unlimited are, on the average, quite inadequate to the risks, and secondly, that all experience of the State control of wages had been very disappointing. We see no reason to recede from either of those positions. That does not imply that we do not sympathise with Mr. Hichens' aspirations; it was the method of application that we criticised.—Ed. E.]

ELASTICITY COEFFICIENT OF THE ETHER.

To the Editor of Engineering.

Sir,—Using the formula $a = (g\,A/w)^{\frac{1}{2}}$ for the velocity of light:—

Let $a = 3 \times 10^{10}$ cm. per second.
$g = 981.17$ cm. per second.
$w = 62.321 \times 0.575 \times (0.0328)^3 \times 0.0022 \times 981.17$ dynes per cubic centimetre.

The terms of w are the weight of water per cubic foot in pounds reduced to a cubic centimetre in grammes and finally to dynes. The second term is the specific density of the ether deduced at 0.575 from the velocity of light in a previous letter on page 18, vol. ciii, January 5, 1917. From these data it follows that the coefficient of elasticity of the ether

$$A = 2468 \times 10^{11} \text{ dynes per square centimetre}$$

and its hydrodynamic pressure on a circular area of diameter 0.5×10^{-8} cm. =

$$B = 2468 \times 10^{11} \times \pi/16 \times 10^{-16} = 484 \times 10^{-5} \text{ dynes.}$$

Excluding the assumption of direct action at a distance and assuming that all Action is purely hydrodynamical originating from the pressure of the ether, two spherical cavities in the ether of diameter 0.5×10^{-8} cm. with their centres 0.5×10^{-8} cm. apart may (neglecting to specify the concealed interaction of the dynamical pressures) repel with the force B; and at a distance of 1 cm. with the force $B \times (0.5 \times 10^{-8})^2 = 1.21 \times 10^{-19}$ dynes. The repulsion of two electrons at this distance is 1.16×10^{-19} dynes, or very approximately the same force.

In H. C. Jones' "Physical Chemistry," 1902, page 138, "the molecular weight of pure liquids is determined by means of their surface tension," and this surface tension hydrodynamically considered must be due to the differences between the internal molecular and ethereal pressures and the external ethereal pressure, each acting at right angles to the plane of contact. Again, page 388, "When substance (*say zinc*) of solution tension P is converted into ions of osmotic pressure P no work is done. Therefore, to convert a substance of solution tension P into ions of osmotic pressure p the maximum work to be obtained is the same as that obtained by transferring the ions from osmotic pressure P to osmotic pressure p," which is exactly the same as the amount of work which can be calculated from a gas in passing from a gas-pressure P to a gas-pressure p. Electrical energy is shown to be equal to the osmotic energy, and finally the calculation is reduced to

$$\pi = 0.058 \log \frac{P}{p}$$

where π is the potential with which a gramme molecular weight of ions is charged. The surface tension, the osmotic pressure, and the electronic charge of each positive and negative ion can each be now directly or indirectly traced to the hydrodynamic pressure of the ether, and a material atomic theory of the ether and of electricity is the result.

If one tithe of the energy devoted to mathematical work based on metaphysical action at a distance were devoted to purely hydrodynamical forces of an atomic ether in accordance with the apparently obsolete materialistic methods of Newton, Faraday, Maxwell, Tyndall and Spencer, the exact nature of gravitational, electro-magnetic, material-elastic, chemical, and even radioactive forces, would be finally deduced; and all the sciences would become branches of one exact science of philosophy as foretold by Spencer, who also held that it was possible to make this generalisation from *à priori* considerations. To the experimentalist, who complacently visualises both positive and negative matter as occupying the same space, all matter is electronic; while to the radioactivist all matter is radioactive, notwithstanding the evidence of Joly's pleochloric halos.

Matter should be defined as that which has inertia and *occupies* space atomically. Elasticity is a property of the kinetic atomic volume, and the terms "infinite elasticity" or "instantaneous conduction" applied to the atom itself are synonyms. Entropy may be defined as the kinetic momentum within an atomic volume, and the quantum of radiation as the product of the secondary motions of molecules or larger volumes (see diagram, page 515, vol. cii), which, reflected by the colloidal surfaces of matter, constitute temperature. With the ether, these surfaces are at an infinite distance, so that there is no temperature other than that due to radiation along infinite lines. Gravity is due to the centrepetal impulse of ether atoms in the proportion a^2/r^2 to the radius a of a revolving planet, as previously described; and material-elastic stresses and strains in the very strongest materials are less than 1 per cent. of the elastic strength of the ether. Gravitational impulses constitute the physical basis of the relativity accelerations of light. No one phenomenon can be thoroughly explained without having the explanation of all; and no explanation can be carried further than the terms of matter and motion.

Yours faithfully,
Fred. G. Edwards.

33, St. Ronans-road, Sheffield,
February 16, 1918.

THE MEASUREMENT OF CURRENT IN ELECTRICAL IGNITION SPARK CIRCUITS.

To the Editor of Engineering.

Sir,—In your issue of February 8, there appears a note by Mr. J. D. Morgan on "The Measurement of Current in Electrical Ignition Spark Circuits." There are several statements therein that are very obscure, and, in one or two cases, incorrect.

On page 137, he states that with a magneto running at constant speed, the current increases with diminution of the spark gap. I would point out that the relation between current and spark gap is very much more complicated than that. Actually, the current increases with increase of gap, rises to a maximum, then rapidly falls to a minimum and then steadily rises again up to the point at which the spark gap length is beyond the spark voltage limit. It should also be stated that the current waves are by no means so simple as those given in Figs. 1 and 2, page 137, and their shape varies very greatly with the spark-gap length.

One would gather from the paper, that Mr. Morgan has some preconceived notions as to the nature of the secondary current and is unconsciously trying to arrange some test which will give results that will agree with these ideas. Thus, on page 138, at the top of column 1, he says: "Both (instruments) gave at all speeds current values which were known to be too high." Why, known to be too high? The secondary current is much too complicated and depends upon too many variables (and some of them are too uncertain), for one to be able to calculate it beforehand.

A thermo-junction and ammeter measures the R.M.S. value of the current, and if different thermal instruments give different readings; this can only be for two reasons: (1) The resistance of the heater is too high, and is, therefore, altering the current wave; or (2) the ammeter may be introducing capacity to earth, which would give a fictitious reading due to capacity currents flowing in the ammeter circuits.

It must not be forgotten that the amount of energy available in each spark discharge of a magneto is very small, and care must be taken as to how much this energy is drawn upon, in order to work the current-recording instrument. This, I am afraid, has been done to an unduly large extent in the apparatus shown on page 138; the reading on it will give, not the low-frequency component of current, but the current feeding the spark when distorted by the insertion of a resistance of 500 ohms to 1,500 ohms. This distortion will be considerable.

The following statement at the bottom of column 1 is surely quite incorrect, viz.: "If the element is made of low resistance, the reading will be determined mainly, if not solely, by the high-frequency component of the current, whilst if wire of high resistance is used the readings will be determined mainly, if not solely, by the low-frequency component." In the first case the reading gives the R.M.S. value of both the high and low-frequency components, while in the second case the reading gives a measure of the high-frequency current, but heavily damped by the high resistance, plus the low-frequency component as modified by the insertion of the high resistance in the secondary current.

Yours truly,
G. E. Bairsto, D.Sc.

Royal Aircraft Factory, South Farnborough,
February 11, 1918.

[To avoid delay we forwarded a copy of Dr. Bairsto's letter to the author of the article criticised and we subjoin his reply.—Ed. E.]

To the Editor of Engineering.

Sir,—From the manner in which Dr. Bairsto uses the words "obscure" and "incorrect" in his references to certain parts of my article, I am bound to infer that those words indicate his considered and final opinion. So far as he is concerned, therefore, there is no call upon me to reply. It may be, however, that the points referred to in Dr. Bairsto's letter have presented difficulties to others who, while not disinclined to agree with him that some of my statements are hazy and wrong, are nevertheless prepared to concede that the opposite opinion is possible on a fuller knowledge of the facts. To dispose of the points completely would require a letter longer than the original article. I can, therefore, only indicate that there was justification for the statements which have been criticised.

If a magneto is running at constant speed, the energy content of the sparks is practically constant over a wide range of spark-gap variation. This statement can easily be verified. Variation of voltage must therefore be accompanied by an opposite variation of current. It is quite likely that Dr. Bairsto has actually observed the effects described in the second paragraph of his letter. I believe I have seen something of the same kind myself. But they do not prove my former statement to be inaccurate.

Regarding Figs. 1 and 2, I stated that they show the general characteristics of the spark discharge. They are not inconsistent with the probability that diagrams complete in every detail would be more complex. As indicating the general characteristics, I stand by them because the evidence for them is incontestibly plain.

The first sentence in paragraph 3 of Dr. Bairsto's letter states that I have some preconceived notions as to the nature of the secondary current, and that I am unconsciously trying to arrange some test which will give results that will agree with those ideas. Doubtless this remark is intended to be mildly sarcastic, but with the alteration of the word "unconsciously" to "consciously," I accept it as literally true. How could anyone proceed otherwise? When it is necessary to decide between instruments which give discordant accounts of the performance of the same machine, the only course open is first to determine theoretically the physical properties of the machine and decide what effects the machine should produce. If the effects are complicated practical considerations may make it necessary to mask or eliminate certain effects in order to make it possible to study the others. In my instrument I have purposely masked the effect of the high frequency or capacity component of the current because I have come to the conclusion (based on intimate experience) that a measure of the low-frequency component gives a better indication of the usefulness of a magneto than a measure of the capacity component, and enables spark generators of different types to be reasonably compared.

When I said in my article that "both instruments gave at all speeds current values which were known to be too high," I had abundant justification in the fact that those values were inconsistent with the known properties of the machines. The caution which Dr. Bairsto gives in paragraph 5 of his letter is one which I imagine anyone would observe. In reply to his suggestion that I have not done so, I can only say that he is mistaken. Simultaneous measurements of the heat energy of the sparks show no appreciable variation when my instrument is put into and out of action. The energy required to operate the instrument is therefore very small.

Regarding the last paragraph of Dr. Bairsto's letter, demonstration is much more effective than assertion and argument. I did not make the statement quoted from my article (which Dr. Bairsto asserts is incorrect) without very careful examination of the evidence. If Dr. Bairsto, or anyone else interested in the problem, cares to come to Birmingham I shall be pleased to show him the experiments on which the statement is based.

Yours truly,
J. D. Morgan.

The Marks and Clerk Laboratory, 13, Temple-street,
Birmingham, February 16, 1918.

The Institution of Automobile Engineers.—The fifth meeting of this Institution was held at the Royal Society of Arts, on Wednesday, the 13th inst., when Mr. Ernest A. Savage read a paper on "The Utilisation of the Data of the Automobile Industry through Bureaux of Information." A telegram was read at the meeting, from the Society of Automotive Engineers, to the following effect: "Expressing great admiration for your effective and magnificent work in the war, the members of the Society of Automotive Engineers assembled in annual meeting to-day send cordial greeting and felicitations. In the common cause for democracy we send assurance of co-operation to the fullest extent." An interesting renewal of the activities of the Institution is shown in its co-operation with the Ministry of Labour in the work of assisting officers to return to civil employment after the war. Before the war, the Institution carried on a regular employment bureau for the purpose of introducing men to jobs, and jobs to men, but this had lapsed during the war. Now, however, it is hoped that the Institution may be able to be of considerable assistance to the Government departments concerned in connection with automotive engineers.

Queensland Railways.—The Queensland Commissioner for Railways, in his annual report, says that the mileage of the State-owned railways open for traffic in Queensland is 5,357 miles, to which should be added 277 miles of lines belonging to local authorities and private companies, making a total of 5,634 miles. The population of Queensland is only 669,467, consequently there are in Queensland only 119 persons to each mile of railway open, and when it is realised how small a percentage of the population is to be found outside the coastal towns the present mileage of railways must appear to be greatly in excess of the population. After paying all working expenses, there is a net revenue of 837,780*l.*, which is equal to 2*l.* 1*s.* 5½*d.* per centum on the total expended on opened and unopened lines. This sum was insufficient by 734,997*l.* to provide working expenses and interest charges for the year. In connection with the deficit on the year's working of 734,997*l.*, the Commissioner said he desired to state that the total loss on these sections of railways that did not pay interest and working expenses during the calendar year of 1916 amounted to 765,352*l.* Of these, 57 sections failed to earn sufficient revenue to pay working expenses and interest on capital, and 32 other sections, while paying working expenses, failed to pay the full interest. It is evident, the Commissioner says, that if the revenue cannot be increased the train mileage must be lessened. This can be done by hauling heavier loads so as to make a smaller number of trains carry the traffic, and this means the use of heavy engines, for which the road has to be strengthened. Unfortunately, financial stringency has prevented much being done in this direction during the past few years, but the work is being undertaken as rapidly as funds will allow.

TRACTION ON BAD ROADS OR LAND.

Fig. 105. CREEPING-GRIP, SENIOR; 50 H.P. DETAIL OF TRACK-FRAME AND DRIVE.

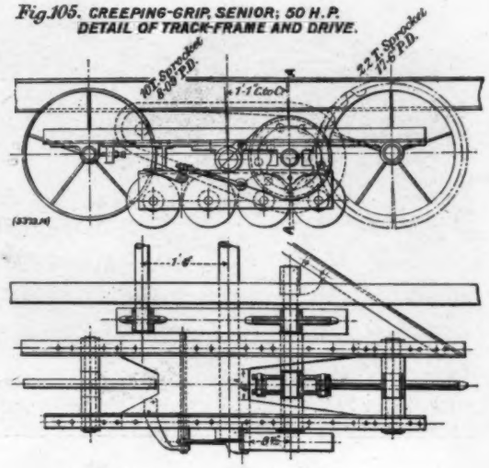
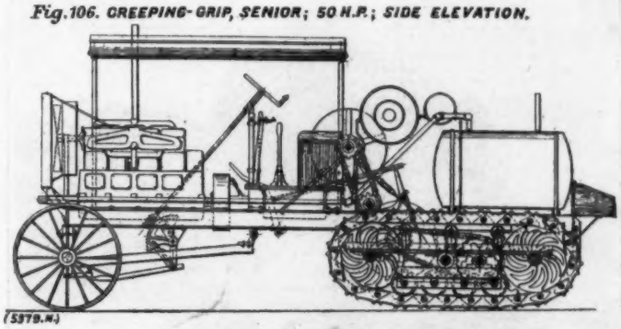


Fig. 106. CREEPING-GRIP, SENIOR; 50 H.P.; SIDE ELEVATION.



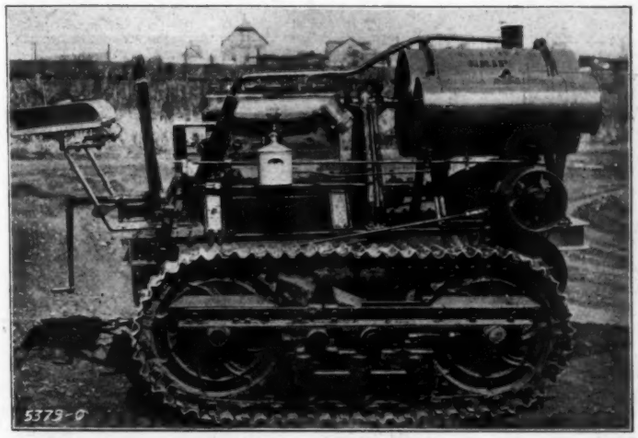


FIG. 108.

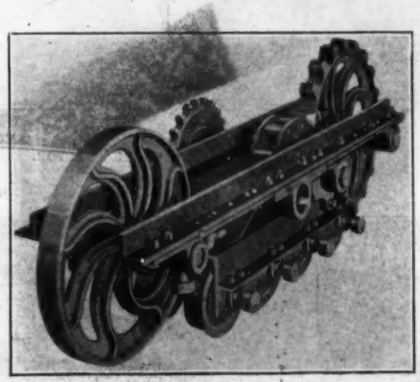


FIG. 110.

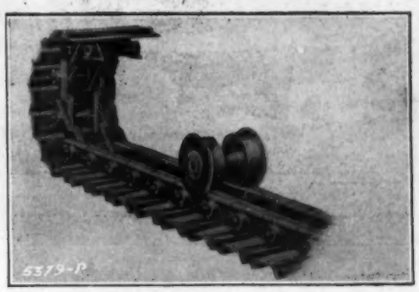


FIG. 111.

FIGS. 105, 106, 108, 110 AND 111. THE CREEPING-GRIP TRACTOR (BULLOCK).

TRACTION ON BAD ROADS OR LAND.*

By L. A. LEGROS, of Acton, Member.

(*Continued from page* 186.)

The Creeping-Grip Tractor (*Bullock*).—The chain tracks in the Creeping-Grip tractors carry the tractor on wheels mounted on short axles fixed in the track frame. The whole of each track frame is pivoted about the axle, which passes through its centre (see Figs. 105 and 106, above). The axle merely carries the track frames. Power is transmitted from the gear-box to two pitch chains, which drive the two chain sprockets; each of these is fixed to a short shaft running in bearings on the track frame between the fixed axle and the sprocket; these shafts each carry a lantern wheel, which engages with the sprocket wheel, the pins in the lantern wheel being of the same diameter as those in the chain links, but the lantern wheel pins engage with each tooth of the sprocket, whereas the chain pins engage with the alternate teeth, Fig. 105.

In the 75-h.p. "Giant," and 50-h.p. "Senior," models the weight is carried on four pairs of wheels in each truck; in the 30-h.p. "Junior," there are only three pairs of carrying wheels. The upper part of the chain is carried on three pairs of wheels in the two larger tractors and on one pair of wheels in the 30-h.p. model. The gear-box is fitted with sliding dog-clutches, the gears being permanently in mesh; the differential gear is of the spur-wheel type. The motor of each model is governed.

The front axle of the 75-h.p. and 50-h.p. models has Ackermann steering and a centrally-pivoted leaf spring which bears on the two axle ends and supports the front of the tractor in the centre; the arrangement, which is similar to that of the Centiped (Phœnix), gives three-point suspension. The 30-h.p. model has a single front steering wheel carried in a forked frame and controlled by a worm and wheel gear.

The small 16-h.p. "Baby," Fig. 108, above, has no front wheel, and is controlled by independent clutching of the two chain tracks; it is possible to reverse either track independently for turning a circle of small radius. Details of the truck and of the track and wheels are shown in Figs. 110 and 111, above.

The Austin Tractors.—The F. C. Austin Drainage Excavator Company, of Chicago, are makers of two models of chain-track tractors. The 35-h.p. tractor, Fig. 112, page 214, like most American low-power tractors is steered by declutching the tracks. This model is supported on six pairs of wheels to each track, which has a normal width of 12 in., but the shoes, which are formed of flat plate with two corrugations, can be widened by bolting to them 30-in. treads of wood reinforced with steel plate; the insistent weight can thus be reduced from 4.7 lb. per square inch to 1.78 lb. per square inch—the lowest figure given in Table II, on pages 144 and 145 *ante*. The arrangement obtained by bolting wide treads to the shoes is liable to the disadvantage of damage, or jamming by stones or sticks due to nut-cracker action; generally tractors working with very low insistent weight are used for cultivating swampy land on which stones do not exist.

The 15-h.p. Austin tractor, Fig. 113, page 214, is very similar in construction to the larger model described, but is supported on two pairs of wheels only for each track; the insistent weight is 4.7 lb. per square inch, and the tractor can be used for hauling a gang of four disc-ploughs, ditching, road-making or grading.

Burford-Cleveland Tractor.—The Burford-Cleveland tractor, Fig. 114, page 214, is of much lighter construction than the machines previously described, having been designed with a view to the exigencies of work in this country, where it is necessary that the headlands should be kept as small as possible. The tractor has no front wheel, steering being effected by brakes on each side of the differential, operated by the steering wheel.

The load is carried by three pairs of wheels, and the slack part of the chain is carried on a single wheel.

The engine is of the ordinary four-cylinder type carried in the main frame by three-point suspension. The exhaust is led through a sleeve jacket on the lower part of the induction pipe; this allows the use of inferior fuel such as paraffin or creosote waste.

The front end of each track frame is formed with a yoke encircling the track chain, and is connected by links to the end of a cross-spring the centre of which is secured to the main frame by U-bolts in the usual manner, the tracks can oscillate about the axis of the back axle. The Burford-Cleveland tractor is shown in Fig. 115, page 214, at work hauling two ploughs.

It is to be noted that in all the vehicles described of this class the torque applied to the sprockets, which tends to lift the front of the vehicle, has the further effect in cases where the track-frame is pivoted, as in the Tracklayer and Creeping-Grip tractor, of increasing the insistent load on the front of the track itself.

The Strait Tractor (*Killen-Strait*).—This tractor, Fig. 119, page 215, presents several original features; the unsymmetrical driving track frame, with its axle placed high and far back, carrying the driving sprocket over which the chain passes; the series of three pairs of large-diameter wheels under which the chain track runs; and the spring arm which, by means of a helical tension spring, keeps the front of the track in contact with the ground.

The drawbar is attached to the frame by a swivel

* Paper read before the Institution of Mechanical Engineers on Friday, January 18, 1918. We regret that owing to the demands upon our space it is not possible for us to reproduce in ENGINEERING all the illustrations showing different types of tractors at work which accompany Mr. Legros' paper.

TRACTION ON BAD ROADS OR LAND.

Fig. 112. 35-H.P. Austin Tractor.

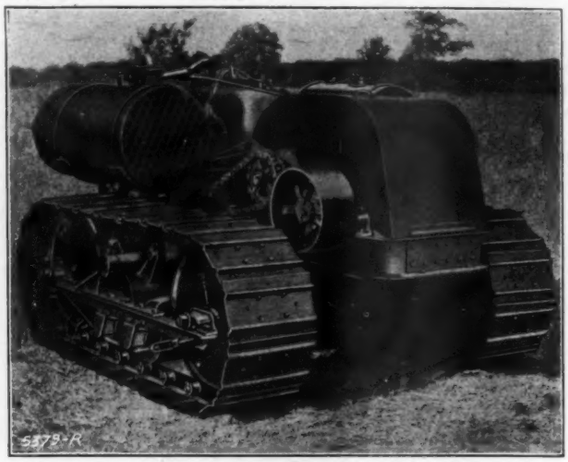


Fig. 113. 15-H.P. Austin Tractor.

Fig. 114. Burford-Cleveland Tractor.

Fig. 115. Burford-Cleveland Tractor Hauling Two Ploughs.

joint forward of the back axle, and it swings clear below the axle. The motor drives through a cone clutch to the gear-box, which is of the sliding-gear type with reverse through bevel gears; the drive to the differential, which is of the bevel-gear type, is effected through spur gears; one driving sprocket is carried on a sleeve to which one bevel wheel is fixed, the other bevel wheel and sprocket being both keyed to the axle. The steering is operated by worm and wheel fixed to a track frame supported on a helical spring. This frame carries a miniature track of 15 treads. The load is carried through three pairs of wheels to the track frame, Fig. 118, page 215; the front axle of these is adjustable for taking up wear. In climbing steep banks or in crossing ditches this front track is sometimes quite off the ground, behaving somewhat similarly to the leading wheel of the Clayton tractor, but with the difference that whereas in the Clayton tractor the track frame is fixed and the whole movement taken by the front wheel, the movement in the Strait tractor is partially taken up by the spring on the front track column and partially by the springs that control the rocking action of the driving tracks.

In the Strait model 3 tractor, Fig. 122, page 215, the power is applied to a single chain track at one side of the vehicle; this track is of similar construction to that of the ordinary model just described. The steering track carried in front is also similar to that already described both in form and in spring suspension, but it travels in the same path as the driving track. The engine is carried to one side of the main or driving track, and the machine is supported on the extreme left by a wide carrying wheel or roller, which runs freely, but can be adjusted laterally on its spring-supported axle.

The gear-box is fitted with a single gear and reverse, but the engine speed is made variable, as in the ordinary motor lorry. An example of work performed by the Strait tractor is given in Fig. 121, page 215. The arrangement of the draw-bar attachment in the Strait tractors is kept low and forward so as to increase the load on the front of the tractor when hauling and consequently to gain adhesion.

The Ball-Tread Tractor (*Yuba*).—In this form of tractor, Fig. 124, page 216, the weight is distributed over the chain track by two rows of steel balls 2.25 in. diameter, and is carried on ball races of annealed cast steel, built into the track frames. The ball-race sections carried on the shoes are of L-form; those on the track frame are, in section, of the form of a circular arc. Thus each ball bears against two faces at right angles to each other on the shoe and against the appropriate portion of the curved section of the track race, Figs. 127 and 128, page 216; it is claimed that this method of carrying the side-thrust renders the arrangement peculiarly suitable for use on side-lying ground. The ball races are kept supplied with heavy lubricating oil when at work.

The track frames are pivoted about the rear axle, which also carries the driving sprockets; the front of each track frame is connected by compression springs, with a bracket carried on the main frame. The driving sprockets are each formed with an internal spur gear, into which gears the pinion carried on the corresponding cross-shaft of the gear-box. The clutch gear is such that the drive to each track, Fig. 129, page 216, can be reversed independently, enabling the machine to be turned in about its own length. The transmission gear is fitted with roller bearings for taking radial loads, and with ball-bearings for axial loads. The gear-box is arranged with two speeds forward, and the same for reverse.

Steering is operated by wire-rope connections from the steering-wheel shaft to the front wheel frame, which runs on ball bearings. An example of the climbing power of this tractor is shown in Fig. 135, page 215. The speed changes are controlled from the operator's seat, and there is a foot accelerator for the motor. The Ball-Tread tractor is shown at work in Fig. 126, page 216 and Fig. 130, page 217.

Martin's Agricultural Tractor.—This is a vehicle of lower power than the majority of those described above; it has been designed with the object of meeting British rather than Overseas conditions. Each track chain passes round two idlers on the track frame and over the track sprocket carried on the main cross-shaft, Fig. 138, page 217. Either sprocket wheel or both can be engaged with the cross-shaft by means of dog-clutches. The tracks are arranged at the front of the machine, which weighs about 30 cwt. including the three-furrow plough.

Steering can be effected by a single central wheel, carried in a castor frame, for use when ploughing, or by a pair of steering wheels mounted in a carriage and operated by means of a pinion and quadrant, Fig. 138, page 217. An example of the Martin tractor fitted with a three-furrow plough is given in Fig. 139, page 217.

(To be continued.)

Electro-Culture Committee.—The President of the Board of Agriculture and Fisheries has appointed a committee to advise in regard to all electrical questions in connection with the carrying out of experiments in electro-culture, and particularly in regard to the construction of apparatus suitable for use on an economic scale, and to the making of such electrical measurements as may be necessary in connection with the experiments. The chairman of the committee is Sir John Snell, M.Inst.C.E. Mr. B. W. Phillips, of the Board of Agriculture and Fisheries, will act as secretary, and all communications should be addressed to him at 4, Whitehall Place, S.W. 1.

TRACTION ON BAD ROADS OR LAND.

(*For Description, see Page* 213.)

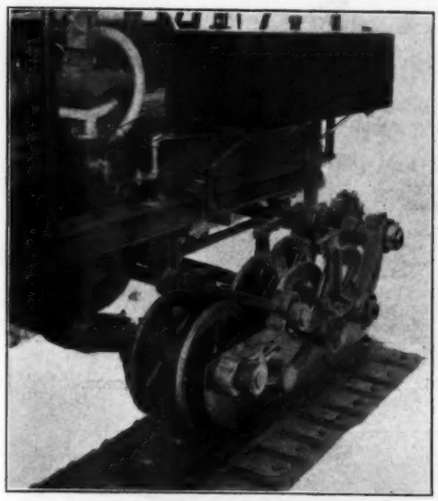


FIG. 118. TRUCK FRAME OF STRAIT TRACTOR.

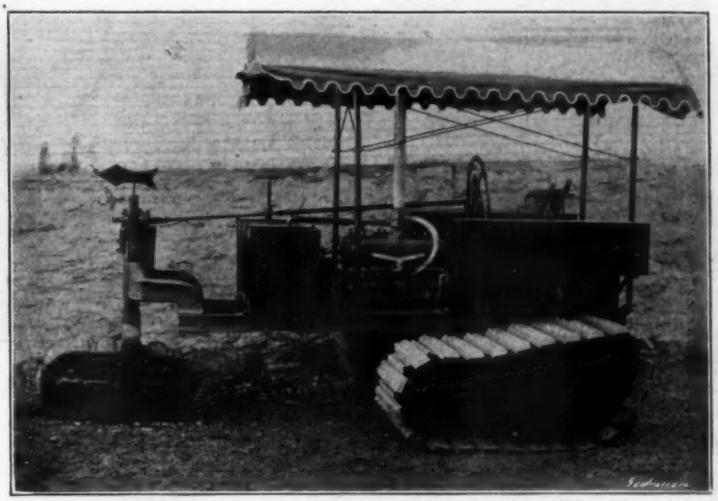


FIG. 119. THE STRAIT TRACTOR (KILLEN-STRAIT).

FIG. 121. THE STRAIT TRACTOR AT WORK.

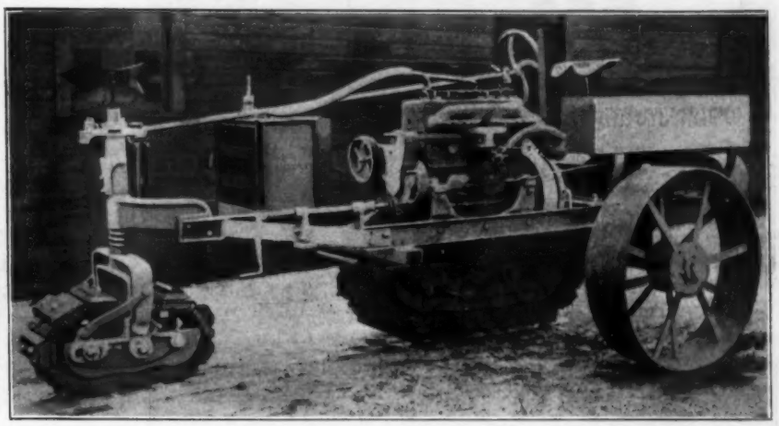


FIG. 122. THE STRAIT TRACTOR (KILLEN-STRAIT).

STEEL SUPPLIES FOR BRITISH MALAYA.

THE trade statistics of the Straits Settlements show that steel was being imported into British Malaya in increasing quantities prior to the war. Doubtless, a substantial portion of this import was absorbed by the large dock and engineering establishments at Singapore and Penang, but the largest share was more probably utilised in the railway extensions, bridge-building and public works of the Federated Malay States, where the Government is promoting the opening up of the country for agricultural and mining development. For four years, the imports and exports at the ports of the Straits Settlements amounted to :—

	Imports.	Exports.
	£	£
1913...	105,198	7,378
1914...	67,015	2,587
1915...	80,659	5,050
1916...	90,622	18,152

The heavier exports of 1916 are accounted for by 10,022*l.* sent to Siam and the Siamese Malay States (where the new railway is being built) and by 6,200*l.* sent to the Federated Malay States. This was not the whole of the steel imports to the Federated Malay States, however, for the trade statistics of the Protectorate give the value of imports of steel for 1916 as 29,905*l.*, compared with 50,836*l.* in 1915.

Until 1916 the United Kingdom was the chief source of supply for Malaya, as will be seen from the following comparative table :—

	1913.	1914.	1915.
	£	£	£
United Kingdom ...	81,916	48,520	50,659
Belgium	16,900	16,866	—
Germany	2,511	847	—
United States ...	2,344	627	17,137
British India ...	—	—	1,085

In these years, the bulk of the exports went to the Federated Malay States and Siam. As showing the changes effected by the war, it is worth while giving the statistics for 1916 separately, since they show the remarkable increase of American imports and the appearance of Hong Kong as a supplier of steel. The new steel-smelting works established in the sister colony appear to have found a ready market for their output in Malaya. The figures are as follow :—

	£
United States	44,814
United Kingdom	35,251
Hong Kong	9,109
British India	824

In view of the extension of railways and other engineering works in the Malay Peninsula, there would appear to be a good market awaiting development for British-made goods, and as soon as the Mother Country is able to resume her normal trade conditions British manufacturers and merchants should not overlook the requirements of Malaya, which is being rapidly developed by British capital and enterprise.

NORWEGIAN SHIPPING CONTRACTS WITH BRITISH YARDS.—A meeting has been held at Bergen at which some 40 shipowners were present, representing 80 contracts with British yards of an aggregate tonnage of 720,000 tons. It was stated at the meeting that Norwegian shipowners had at present between 90 and 100 running contracts for vessels with British yards, the aggregate tonnage amounting to 850,000 tons. Although most of the holders of British contracts are domiciled in Bergen, it was decided that a central committee should be formed, comprising the whole country, so that the interests of the contract-holders might be duly looked after in these difficult times.

PRICES OF IRON AND STEEL.—The Minister of Munitions has issued a notice, dated the 14th inst., modifying as from the 1st inst., the prices and extras fixed by the General Permit of November 1, 1916, for high-speed tool steel and scrap therefrom. He has also issued, on the same day, a notice altering, as from the 14th inst., the price of standard quality bar iron.

BRITISH AIRCRAFT PRODUCTION.—The Minister of Munitions makes the following announcement :—Sir William Weir has been appointed a member of the Munitions Council in charge of Aircraft Production, at the same time retaining his position on the Air Council. Sir Herbert Hambling has vacated the office of Member of Council in charge of Finance.

CYLINDERS FOR DISSOLVED ACETYLENE—ERRATUM.—We regret that a general remark we made in our Note on "Cylinders for Dissolved Acetylene," published on page 155 of our issue of February 8, should have lent itself to an unintended interpretation. We said : "We notice, however, that some chemical action, due possibly to the charcoal or its impurities, seemed to have been observed in a few cases in which the cylinders became hot while the gas was blown off." Instead of "charcoal" we should have said "carbonaceous matter." The cases referred to occurred with kapok fillings ; kapok is essentially carbonaceous, and our remark was intended in that sense. Since, however, the filling materials are distinguished in the report as (*b*) charcoal and (*c*) kapok, we have to correct the statement to make it clear that it does not apply to the former type of cylinders, all the more so, as the remark may appear to reflect upon one particular firm, the Acetylene Equipment Company, Limited, of South Lambeth-road, which, we understand, is the sole manufacturer of cylinders filled with charcoal porous material.

TRACTION ON BAD ROADS OR LAND.

(*For Description, see Page* 213.)

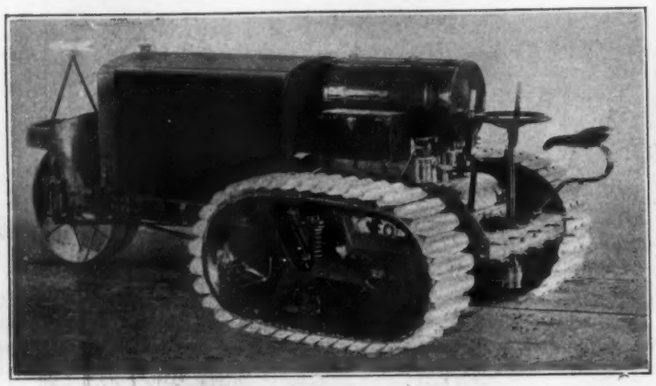


Fig. 124. The Ball-Tread Tractor (Yuba)

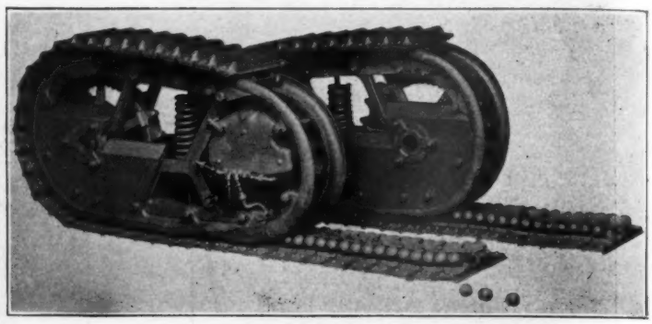


Fig. 125. Truck of the Ball-Tread Tractor.

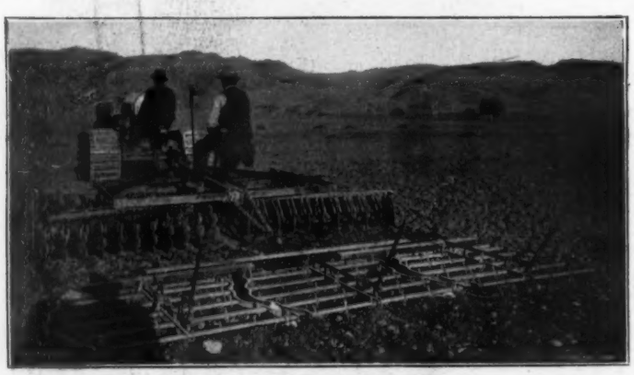
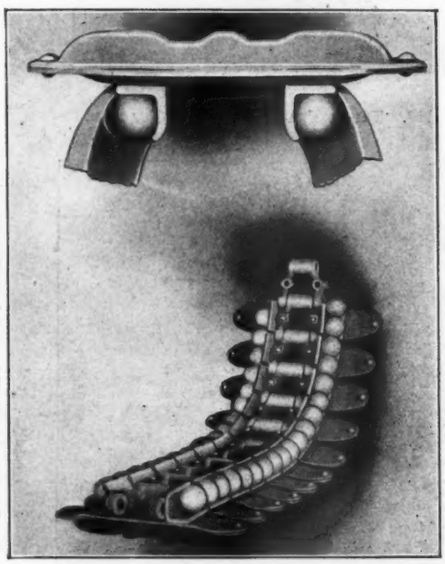


Fig. 126. The Ball-Tread Tractor at Work.



Figs. 127 and 128. Details of Ball-Race; Ball-Tread Tractor.

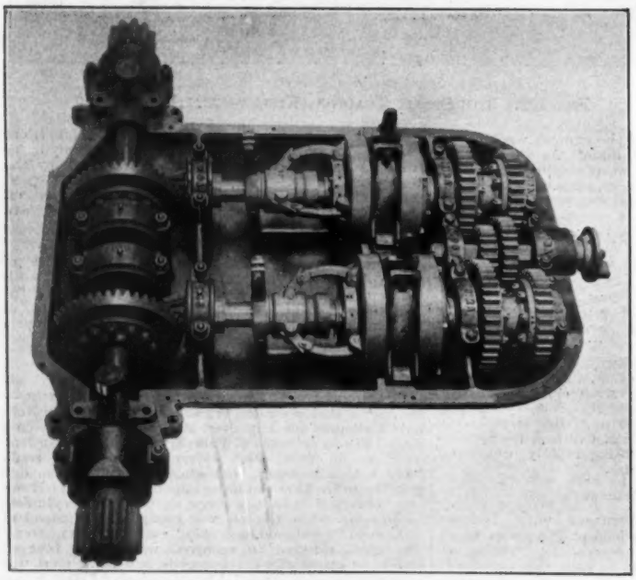


Fig. 129. Driving Gear of Ball-Tread Tractor.

Fig. 135. Climbing Test of Ball-Tread Tractor.

Fire Control on the Copper Queen Mine.—The Copper Queen mines in Arizona have many shafts; the deeper portions are ventilated by fans, in the shallower portions natural ventilation is sufficient. There have been several fires, one of which is still being kept under check. Before the American Institute of Mining Engineers (Bulletin, January, 1918) Superintendent Gerald Sherman, of the mines, described the preparations, which are being made to check any new fire, and in particular the concrete fire doors. Each door is held open by a latch, which is controlled by an air cylinder acting against a counterweight. When a valve in the compressed-air main is opened anywhere, the weight throws the latch and closes the door, which may be reopened by hand. If anything should go wrong with the main, the doors would close. When a fire breaks out, the alarm is given, the number of the district being flashed on all the electric lights; the doors are closed, and the fans shut down; the men are hauled up, and the shaft sprays turned on. When a plan of fighting the fire has been decided upon, some fans may be restarted.

TRACTION ON BAD ROADS OR LAND.

(*For Description, see Page* 213.)

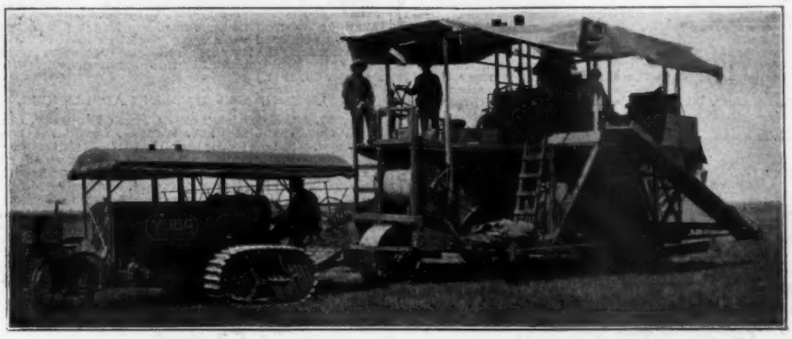


FIG. 130. BALL-TREAD TRACTOR HAULING HARVESTER.

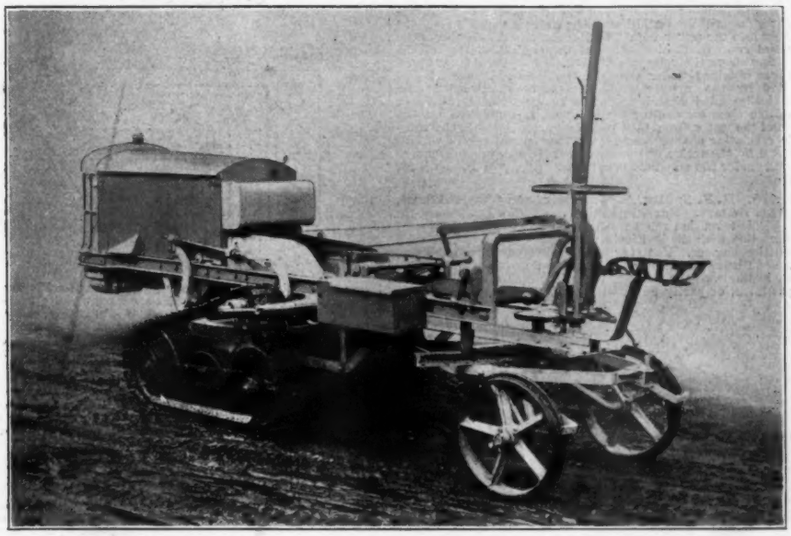


FIG. 138. MARTIN'S AGRICULTURAL TRACTOR.

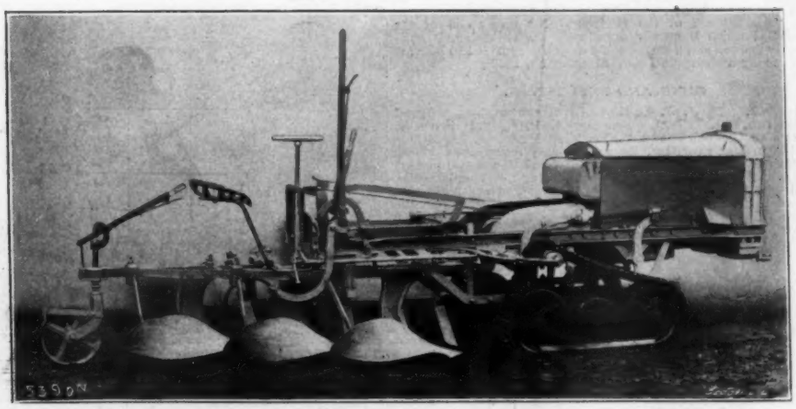


FIG. 139. MARTIN'S AGRICULTURAL TRACTOR FITTED WITH THREE-FURROW PLOUGH.

THE LIBERTY MOTOR.—We read in *The Iron Age*, New York, the aeroplanes of the United States fighting forces, equipped with Liberty motors, undoubtedly will be better engined than any aircraft now being built. The new Liberty engine will develop over 400 h.p. at 1,625 r.p.m., the highest possible speed with the present propeller design.

THE ITALIAN OUTPUT OF LIGNITE.—According to the *Rivista Tecnica delle Ferrovie Italiane*, the output of lignite in Italy from January 1 to August 31, 1917, amounted to 1,003,992 tons. Of this total, Tuscany produced 721,422 tons, and in this latter figure for Tuscany the output of the province of Arezzo entered for 524,448 tons.

CATALOGUES.

Cutting Compound.—Messrs. James Macneill and Sloan, Limited, Barrowfield, Glasgow, send a circular referring to the drilling composition which they have made for many years. The composition is delivered as a powder and dissolves in hot or cold water ready for use.

Steam Trap.—A "dynamic-impulse" steam trap made by Messrs. James Baldwin and Co., Keighley, Yorks., has inlet and valve areas of same size. The drain water from steam pipes is led into the trap and discharged from it by impulses acting at about 60 per minute. It is a very compact fitting, simple in construction and easily adjustable. It discharges the water at a high temperature—205 deg. F.

Gas Furnaces.—The Davis Gas Stove Company, Limited, Luton, send a reprint of some special articles which appeared in *The Gas Journal* describing their works and a number of the furnaces and burners manufactured by them. The publication gives a very clear and informing account of the construction and uses of these appliances. The illustrations are very distinct in detail.

Electric Fuse Boxes.—The British Insulated and Helsby Cable Company, Limited, Prescot, Lancashire, send a single-leaf catalogue of their Prescot fuse boxes. These are of the non-sealing type for single cables. They are fitted with porcelain bridge fuses, all live metal parts are protected so that they cannot be inadvertently touched, and the metal is not allowed to scatter when the fuse operates. They are made for 25 amperes at 250 volts and also for 50 amperes to 300 amperes at 500 volts. These fittings are very neat, substantial and convenient, and fully comply with the Home Office regulations.

Electric Switch Gear.—A simple design of iron-clad, oil-break switch gear, to provide a totally-enclosed switch for circuits of small capacity up to 700 volts, is described in a catalogue from the British Thomson-Houston Company, Limited, Rugby. The maximum ratings are: Non-automatic, two or three-pole for 60 amperes; automatic, two or three-pole with series trip coils for 3 amperes to 60 amperes. All parts are readily accessible, and any of the usual automatic or other accessories can be fitted as required. The pedestals are either plain supports or similar to those used for large-capacity types, with which they can be put in line. The catalogue contains full details and illustrations.

Oil Recovery.—The Industrial Waste Eliminators, Limited, 20, High Holborn, London, W.C. 1, send catalogues of their turbine-driven machines for extracting cutting oil from metal cuttings and small finished parts; cleaning waste and fabrics from oil and filtering oil. A specially designed centrifugal extractor is used, the blast of steam plays on blades set in the lower and outer part of the basket, and the exhaust steam escapes to melt and wash out the oil. The machines are complete in all details, and supplied ready for setting to work, only a steam pipe connection having to be fitted. Increasing attention is being given to the recovery of waste oil, and it is certainly best to use specially-designed machinery.

Electric Bulkhead Fittings.—A very carefully-designed set of these fittings is shown in a catalogue received from the Wardle Engineering Company, Limited, 196, Deansgate, Manchester. Two fixing holes are in a central vertical line, so that the fitting is attachable to a projection or narrow pillar. The front, or lid, held by two screws with wing nuts, can be slacked and swung open on the lower screw, no hinge fitting being used. Fixing and wiring are rendered very easy and rapid. For dangerous buildings there is a special design to fix outside the window, with flat glass front and lid at the back so that renewals may be made from outside. These fittings are used in chemical and other works as well as in ships. One of the designs is suitable for either one or two lamps.

Cotton Baling Machines.—The former method of pressing cotton into bales for transport was by vertical pressure: the cotton was thrown into a well and pressed down. An improved method, the invention of Mr. A. E. Cummins, is embodied in a machine made by Messrs. David Bridge and Co., Limited, Castleton, Manchester, who send a special catalogue describing it. An hydraulic ram with ropes and pulleys, a baling press and a long box for receiving the loose cotton are laid on the ground in line ahead. The loose cotton box has doors all along the top, and these open and shut by power mechanism. The cotton is thrown in quite loose, the top doors shut and the charge drawn into the press chamber, where a final and powerful pressure is applied and the bale tied with hoop iron. While the bale is being finished in the chamber the top doors of the loose cotton box are automatically opened and another charge is being thrown in. The machine will press and tie about 50 bales of 400-lb. each per hour of fine dry indian cotton. It is also used for baling jute, china grass, hemp, wool and many other materials. The bale has more oneness in its composition than the vertical press bale which forms in sections. The total weight of the machine is about half that of the vertical press, and the plan of laying it out on the ground makes it cheaper to instal and work and easier to keep in repair. In both design and construction it is a fine example of the application of skill and special experience to effecting a general improvement: quality and cost of product, speed of production, and cost of fixing and upkeep are all improved. That it takes more floor space is no disadvantage in the places where such machines are used.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

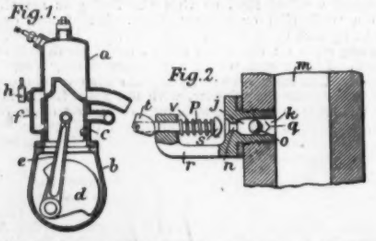
ELECTRICAL APPARATUS.

111,929. British Insulated and Helsby Cables, Limited, and J. Brotherton, Helsby. Electric Cables. (1 *Fig.*) January 2, 1917.—This invention has reference to flexible cables in which the conductors, in addition to being provided with the necessary thickness and quality of rubber compound to ensure electrical insulation, are provided with a sheathing of vulcanising rubber compound of substantial thickness to give mechanical protection; such cables are now well known as "cab-tyre" cables. According to the present invention, the vulcanising sheathing is surrounded by a woven or braided metallic sheathing, preferably of steel wire. A is the electrical conductor. B is the di-electric sheathing which is relied upon, in the main, to ensure the electrical insulation of the conductor. C is the sheathing of vulcanising

rubber compound of substantial thickness, and forms a tough, flexible covering designed to afford protection against mechanical injury and against access of moisture to the electrical insulation. D is the metallic sheathing which is braided or woven somewhat openly, but so as to provide considerable longitudinal strength, and which is anchored to the terminals, and which, by taking any tensible stress to which the cable may be subjected, relieves the electric conductor and the terminal portions thereof of strain. E is an outer sheathing of vulcanising rubber compound, and forms a tough, flexible covering designed to protect the metallic sheathing from deterioration by moisture and from mechanical injury. (*Accepted December* 28, 1917.)

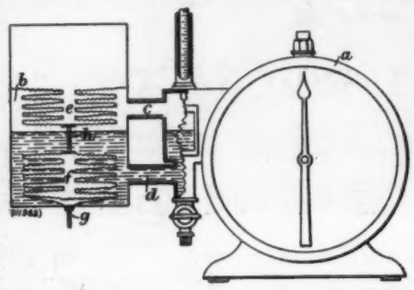
GAS ENGINES, PRODUCERS, HOLDERS, &c.

111,918. H. Calvert, Dalton-in-Furness. Internal-Combustion Engines. (3 *Figs.*) December 21, 1916.—This invention relates to internal-combustion engines of the two-stroke type, provided with a valve which commences to admit air to the crank chamber from the atmosphere at the end of the explosion stroke in advance of the gas or mixture. According to this invention, the valve for admitting air to the cylinder from the atmosphere is adapted to control a port which can be opened or closed at the will of the driver. *a* is the cylinder, *b* the crank-case, *c* the piston, *d* the crank, *e* the connecting rod, and *f* the transfer passage. According to this invention, there is screwed into the transfer passage of the cylinder at *h* a small fitment embodying this invention, such as is shown in Fig. 2, and which has a chamber *j* with a large orifice *k* opening to the interior of the transfer passage *m*, and a smaller orifice *n* at the exterior of the chamber *j*, and within this chamber is a movable ball *o* which, when pressed against the smaller orifice *n* of the



chamber by the pressure from the gases in the crank chamber, as the piston is travelling down, closes the orifice *n*, and which, when released from such pressure, is moved from the smaller orifice of the chamber by the suction in the crank chamber, as the piston is travelling up, thus leaving the orifice open, if and provided the plug *p* hereinafter mentioned is withdrawn from the outer side of the said smaller orifice. On the fitment shown is disposed a bracket *r* on which is mounted a plug *p* having a head *s*, which is adapted to close from the outside the orifice *n* when desired. The plug *p* is adapted to be retracted by the cam *t* under control of the driver, and thus leave open the orifice *n* when desired, and when the plug *p* is so retracted the spring *v* tends to keep it firm in the retracted position, but so soon as the cam *t* is released the spring *v* tends to push the head *s* of the plug *p* automatically against, and thus to close, the orifice *n*. The orifice *n* is preferably kept closed when starting the engine. (*Accepted December* 28, 1917.)

111,962. South Metropolitan Gas Company, and J. M. Somerville, London. (1 *Fig.*) March 14, 1917.—According to the present invention, an escapement is employed to ensure a regular rotation of the meter drum which is driven by the pressure of the gas, and also means for varying the water-level in the meter are used, comprising a system of aneroid chambers partly enclosed in an hermetically-sealed compartment and partly immersed in a vessel containing water and communicating with the water space of the meter. *a* is the meter casing containing a drum driven by the gas pressure and caused to maintain a constant speed of rotation by means of escapement mechanism of any suitable kind. *b* is a separate chamber communicating with the interior of the meter casing by pipes *c*, *d*, above and below the water-level. Within the chamber *b* is a system of aneroid chambers *e*, *f*, the portion *e* of which is hermetically sealed and the portion *f* open to the atmosphere by the pipe *g*. The portions *e*, *f*, are connected together mechanically by a rod *h*. The level of the water in the chamber *b* is the same as that in the casing *a*, and completely submerges the portion *f* of the aneroid system. The space between the water-level in the chamber *b* and the hermetically-sealed portion is open to the pressure of the gas passing through the meter so that the pressure on the surface of the water is the same throughout. The effect of the varying atmospheric conditions upon the upper hermetically-sealed chamber *e* is such as to cause the membranes to expand and contract under the varying conditions. In the action of such movements, the rod *h* causes the rise and fall of the collapsible body *f* placed within the water; thereby creating a displacement of the water when the atmospheric effect causes a contraction of the hermetically-sealed chamber and an induction of the liquid when the expansion of the upper chamber causes a compression of the lower collapsible chamber *f*. The drum, therefore, being provided with a regular delivery, when



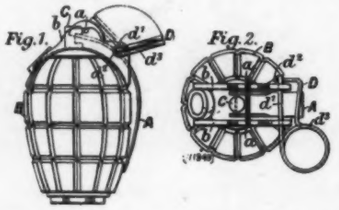
the atmospheric conditions consist of a high barometer and a low temperature (thus contracting the upper chamber of the automatic regulator of the water-level), the water is expelled from the chamber into the meter and so, in accordance with the rise of the level and consequent diminution of the cubical content of the measuring drum the volume delivered, is less than that which would be obtained under standard conditions. The converse is obtained by the reverse action, viz., the expansion of the hermetically-sealed chamber and the compression of the lower collapsible chamber causing a void, which is followed by the return of the water from the meter-drum chamber into the automatic regulating chamber, and under these conditions the volume delivered by the meter will be greater than that which would be received under the standard conditions. (*Accepted December* 28, 1917.)

111,936. R. F. Spiller, A. M. Patton, and Charles Hurst, Limited, Belfast. Sparking Plugs. (3 *Figs.*) January 10, 1917.—This invention relates to ignition plugs such as are used in connection with the ignition of the explosive gases in internal, combustion engines. The plug has the electrode *a* made hollow, its top end being closed by a terminal *b* and provided with a hole a^2, for instance, at the spark end a^3. The hollow interior of the plug is filled, or partly filled, with fluid, for example, water, or

mercury, and the hole a^2 is then closed by welding or otherwise. When the electrode is heated by the gases in the engine, the fluid in the electrode will circulate therethrough and help to transmit the heat from the end a^3 to the comparatively cool upper end, and so help to distribute the heat and to reduce its intensity at the "spark" end of the electrode. The upper end of the electrode, which is usually outside the engine casing, is comparatively cool, and heat-radiating fins *c* are provided to increase the cooling action. (*Accepted December* 28, 1917.)

GUNS AND EXPLOSIVES.

111,949. F. J. J. Gibbons, Wolverhampton. Hand Grenades. (2 *Figs.*) February 5, 1917.—This invention relates to the well-known "Mills" hand grenade. According to the present invention, the safety pin is constructed in the manner of a brooch safety pin, *i.e.*, it has a hook or guard portion which makes spring-engagement with the end of the pin which protrudes through the apertures in the lugs and which must be released therefrom before the pin can be withdrawn from the grenade. A is a lever which, by a pin *a*, firmly secured thereto, is so pivotally mounted in recesses formed in lugs *b*, formed



integrally with the shell B of the grenade, that the upper extremity of the lever A inter-engages with a recess formed in the upper end of the firing pin C, and sustains the pin C against the force of a helical spring contained within the shell of the grenade, in position to strike, when released, a blow on the percussion cap placed in contact with a time fuse contained within the shell. Prior to the delivery of an attack, grenades are served out with the levers A locked in the safety position by means of a safety pin D, the straight portion d^1 of which is inserted through apertures formed in the lugs *b*, thereby making pressure contact with the back of the lever A and the hooked portion d^2 of the pin D entered into spring-engagement with the end of the straight portion d^1, which protrudes from the aperture formed in the lug *b*. Until the hook portion d^2 has been pressed away from the portion d^1, and thereby disengaged therefrom, the pin cannot be withdrawn. To facilitate the withdrawal of the safety pin, the pin has a ring d^3 formed integrally therewith of sufficient diameter for the insertion of a finger of the thrower. The grenade and lever A being grasped by the throwing hand, the thumb or finger of the same hand can readily detach the hook from the point and the finger of the other hand can withdraw the pin, setting the lever free to liberate the firing pin when the grasp of the hand is released by throwing the grenade. (*Accepted December* 28, 1917.)

LIFTING AND HAULING APPLIANCES.

111,940. The British Trolley Track Company, Limited, E. A. Goddard and V. A. Wallace, London. Overhead Runways. (4 *Figs.*) January 17, 1917.—This invention provides means for operating a switch of an overhead runway. A and B are fixed runways, the ends of which are carried by a bracket C, and D is a length, or tongue, of runway which may be turned about a pivot axis to receive or deliver traffic from or to either runway A or B, as required, the end of the runway D, which is towards the runways A and B being carried by a sliding bracket E. F is a sprocket wheel rigid with a crank G, the crank-pin of which is connected with the sliding bracket E by a link H. A stud K, about which the sprocket wheel and crank turn, is fixed to a wrought-metal bracket M. A chain is passed over

Fig.1.

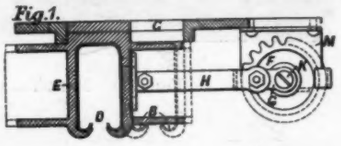
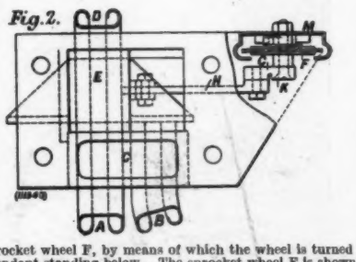


Fig.2.



the sprocket wheel F, by means of which the wheel is turned by an attendant standing below. The sprocket wheel F is shown to have been turned to bring the crank G into its extreme position in one direction, having thereby brought the switch D into alignment with the runway A. By turning the sprocket wheel F so far as it can be turned in the opposite direction, the crank G will be turned into its extreme position in such direction and will bring the switch D into register with the runway B. If, when the crank G has been turned into either of the extreme positions, the centre of the crank-pin is in a line which connects between the centre of the pivot-pin of the bracket J and the centre of the stud K, the switch bracket E will thereby be prevented from moving the crank back. (*Accepted December* 28, 1917.)

MOTOR ROAD VEHICLES.

111,872. S. E. Alley, Polmadie, Glasgow. Motor Vehicles. (2 *Figs.*) May 4, 1917.—The invention relates to engine crankshafts and differential gear combinations of the kind such that the usual balanced drive given by that gear may be transmitted from driving members co-axial with and at opposite ends of that shaft to the road wheels of a motor vehicle. Each crank A, B with its webs A^1, B^1 is a separate piece, and the crank-pins are bored to receive spindles A^2, B^2, on the ends of which are pinions A^3, A^4, B^3, B^4. The pinions A^3, B^4 gear with pinions D, E on shafts D^1, E^1, spigots F, G on the ends of which engage in apertures in the form bearings for the outer

Fig.1.

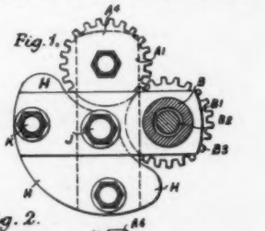
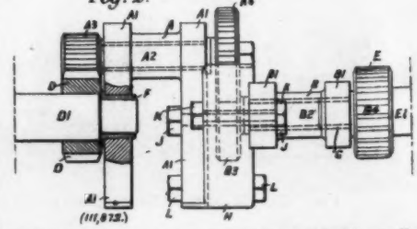


Fig.2.



crank-webs A^1, B^1. The adjacent pinions A^4, B^3, on the spindles A^2, B^2 gear with one another, and thus is the differential train completed. The two cranks A, B, arranged at approximately right angles to one another are connected together by a distance-piece H, of kidney-like shape, which forms a crank counterbalance, a substantially axial bolt J passing through both the adjacent webs A^1, B^1, and the distance-piece H, while an additional bolt K further secures the web A^1, and a like bolt L the web B^1. The shafts D^1, E^1, are supported in any convenient form of bearing and of course transmit the final drive differentially. (*Accepted December* 28, 1917.)